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Energy Research and Development at The University of Utah

The University of Utah

multi-disciplinary, multi-scale, multi-physics applied energy research

Philip J. Smith
professor & director

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Energy & Geoscience Institute
at the University of Utah

fossil energy
geothermal systems
environmental engineering



Center for **E**xcellence in **N**uclear
Technology, **E**ngineering, and **R**esearch



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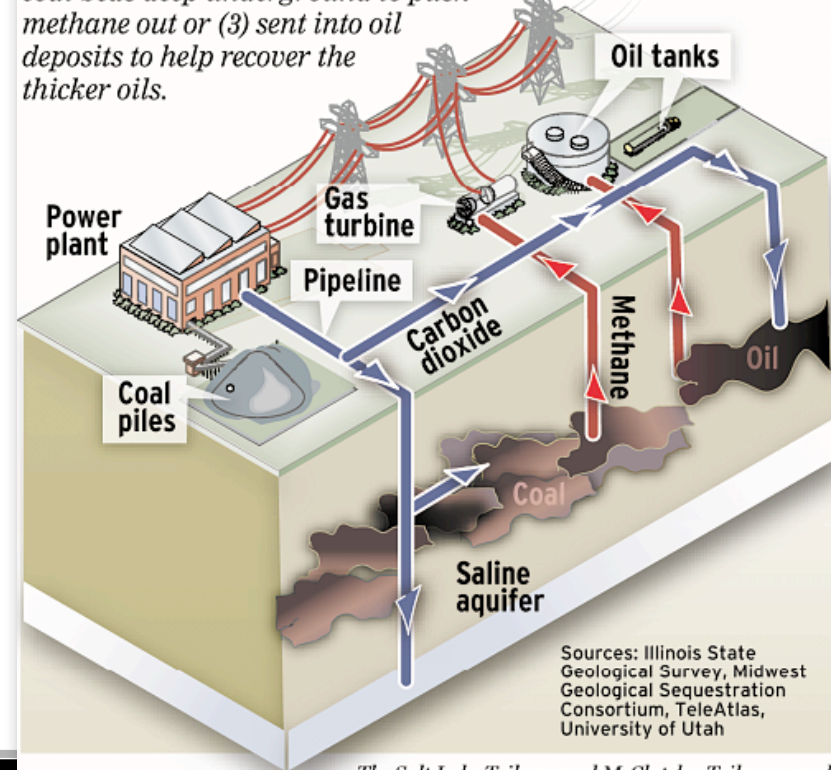
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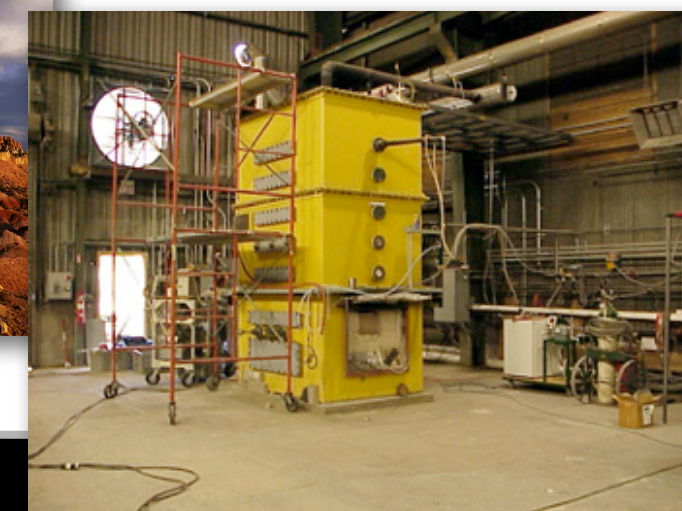
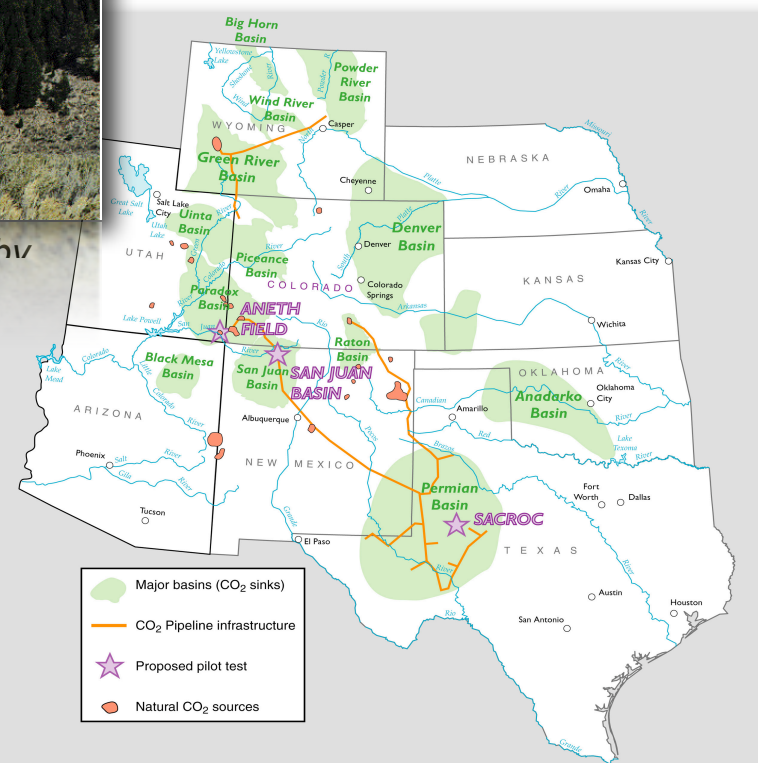
Carbon Sequestration Models

The University of Utah's Clean Coal Center is examining several ways that utility companies with coal plants could bury their carbon dioxide emissions, which are greenhouse gases. The CO₂ could be (1) pumped into saline aquifers for storage, (2) forced into coal beds deep underground to push methane out or (3) sent into oil deposits to help recover the thicker oils.



Sources: Illinois State Geological Survey, Midwest Geological Sequestration Consortium, TeleAtlas, University of Utah

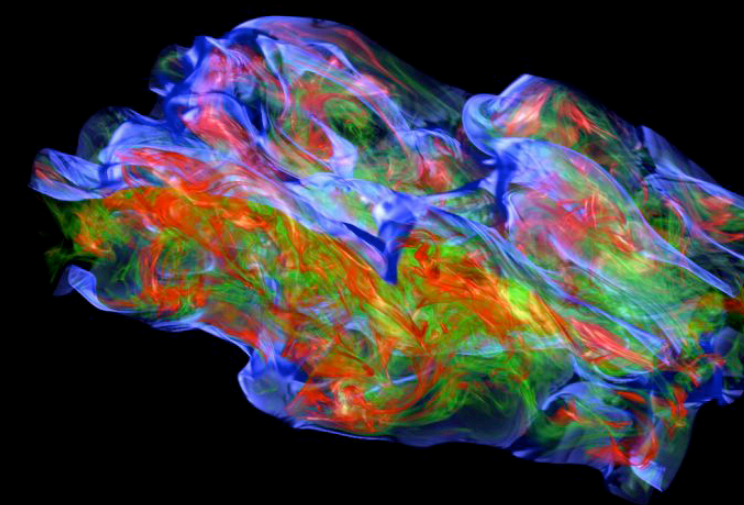
The Salt Lake Tribune and McClatchy-Tribune graphic



ICSE

research, education & technology in
clean & secure hydrocarbon energy

The University of Utah



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\$8.5million/year

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UC³: Utah Clean Coal Program

\$2million/year

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UHOC: Utah Heavy Oil Program

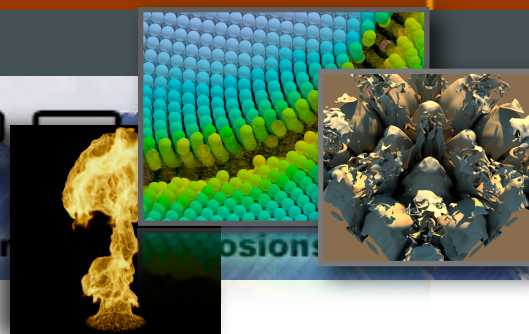
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C-SAFE

Center for the Simulation of Accidental Fires & Explosions



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C-SAFE: Center for Simulation of
Accidental Fires & Explosions

\$3.5million/year

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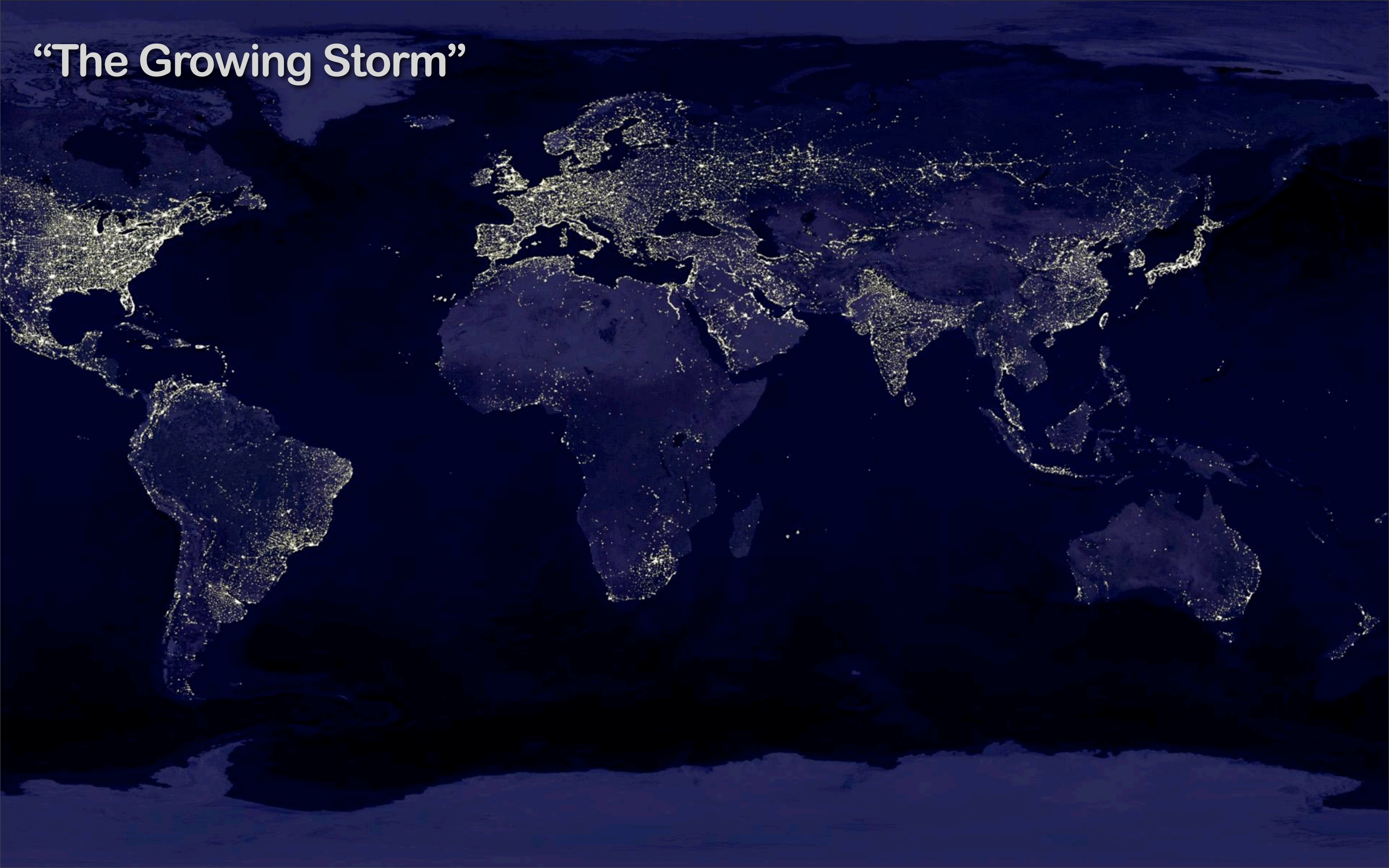
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Energy Production in a Carbon Constrained World

The University of Utah

multi-disciplinary, multi-scale, multi-physics applied energy research

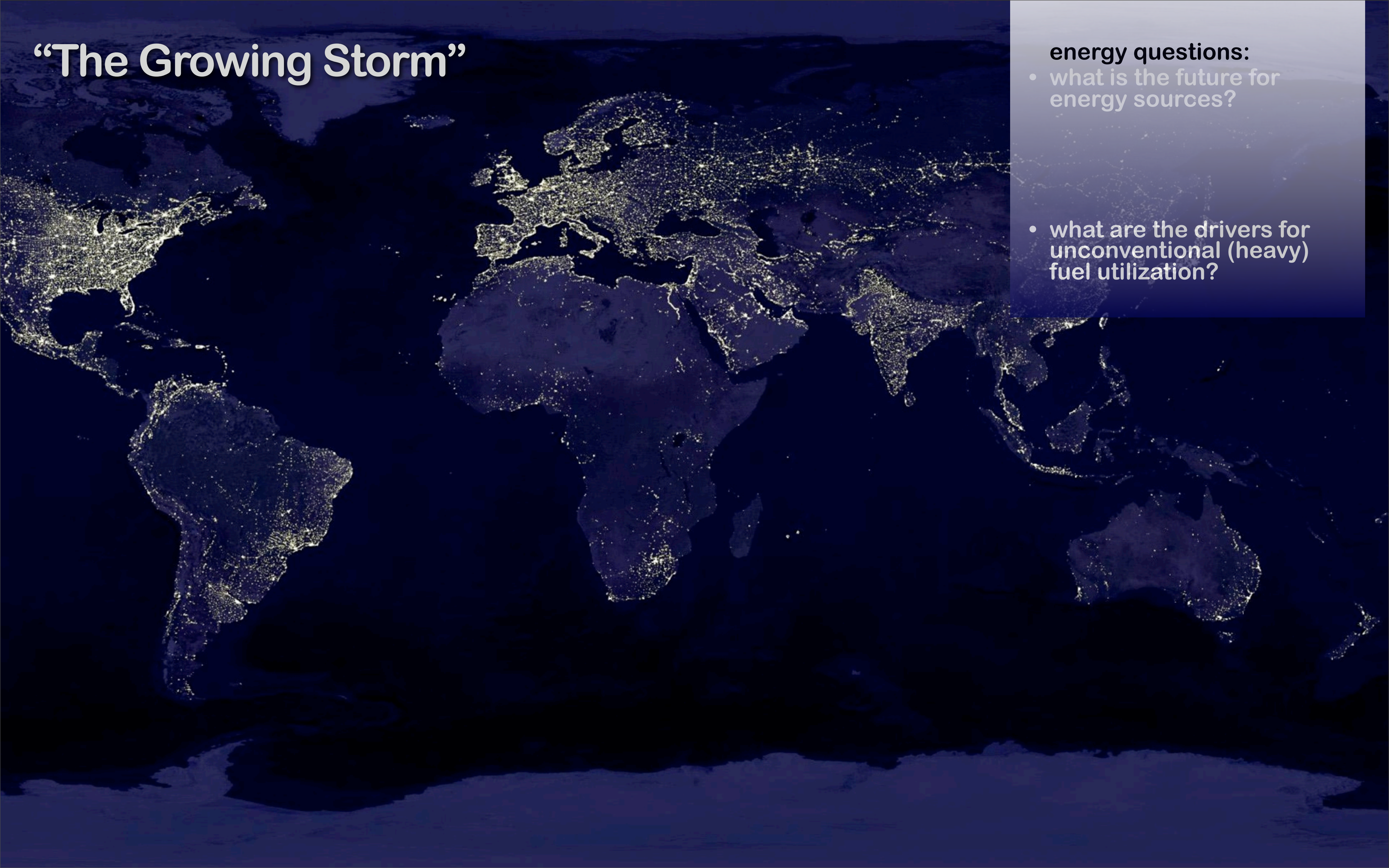
“The Growing Storm”



“The Growing Storm”

energy questions:

- what is the future for energy sources?
- what are the drivers for unconventional (heavy) fuel utilization?



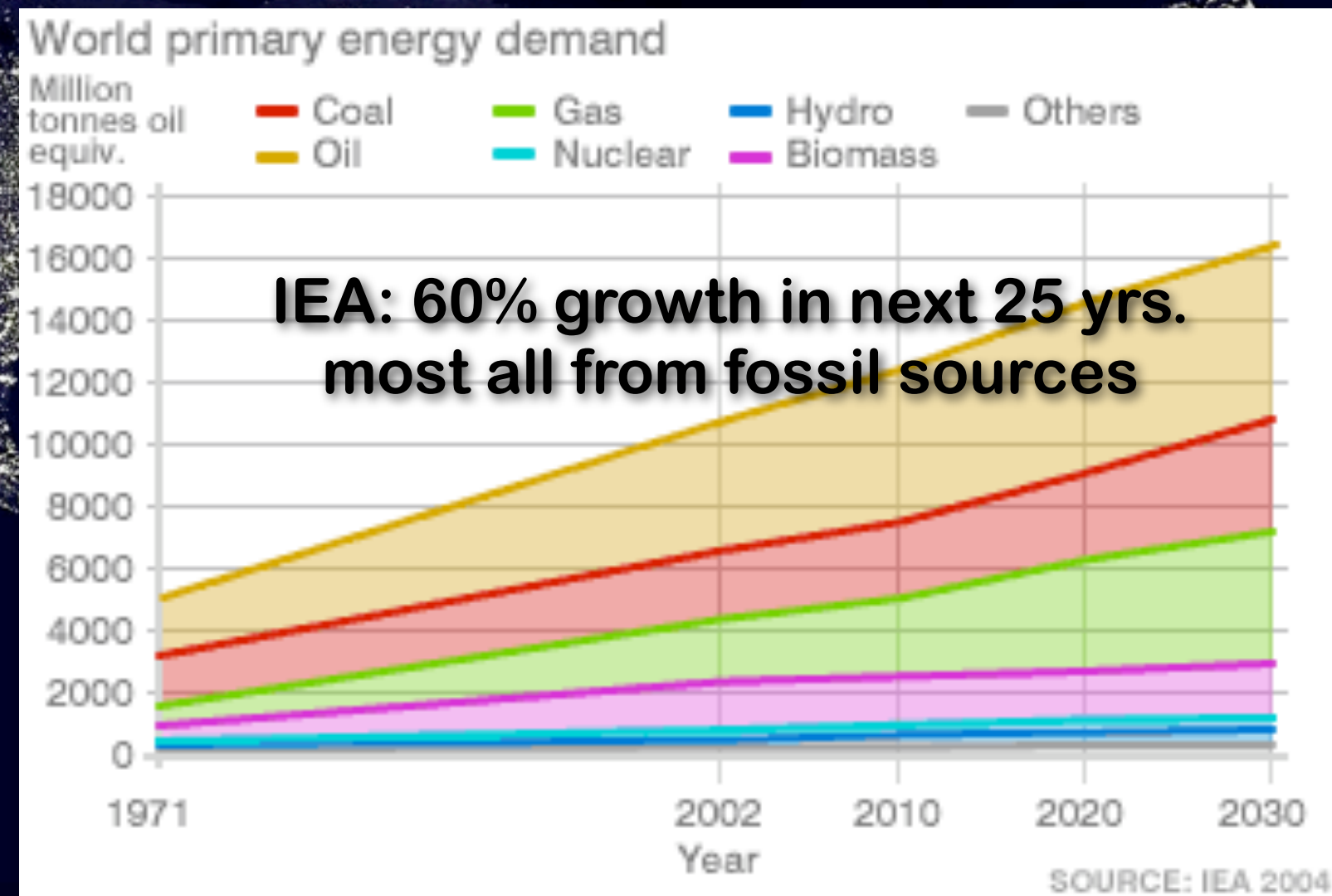
“The Growing Storm”

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- **increasing energy demand**

“The Growing Storm”

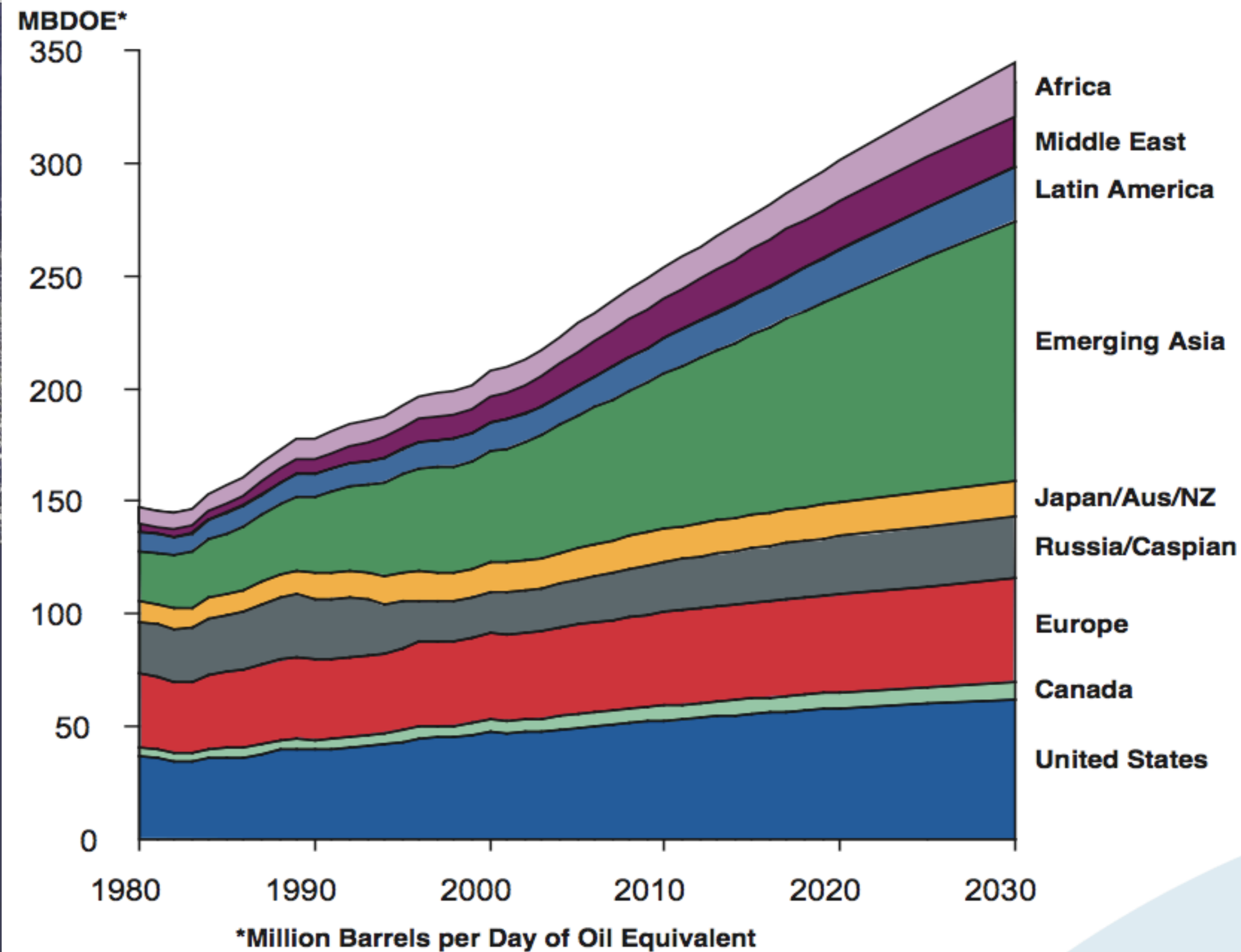


energy questions:

- what is the future for energy sources?
- what are the drivers for unconventional (heavy) fuel utilization?

- increasing energy demand
 - developing nations: China & India
- rising cost of oil & gas & low cost of coal
- huge global reserves of coal & unconventional heavy oil

World Energy Demand

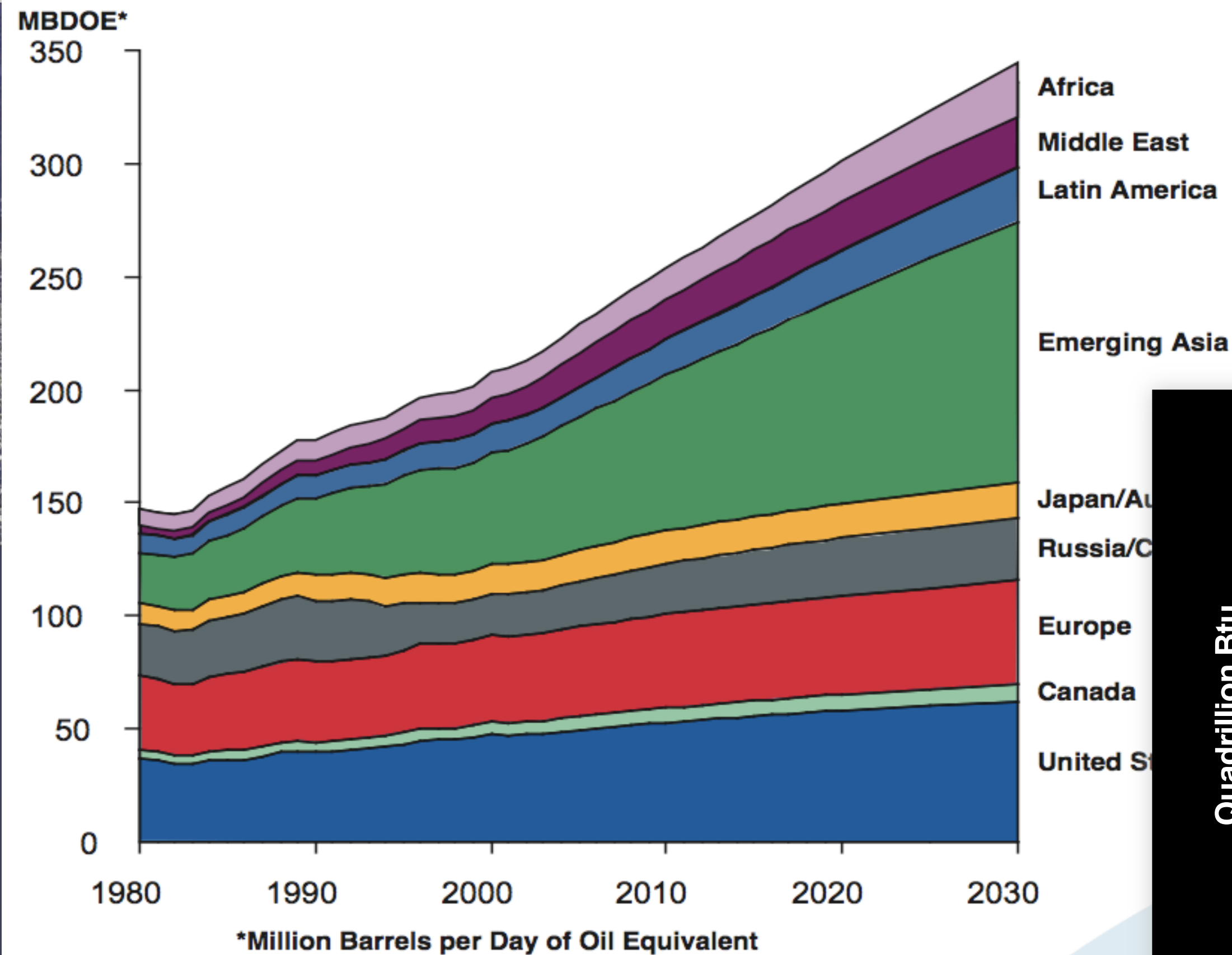


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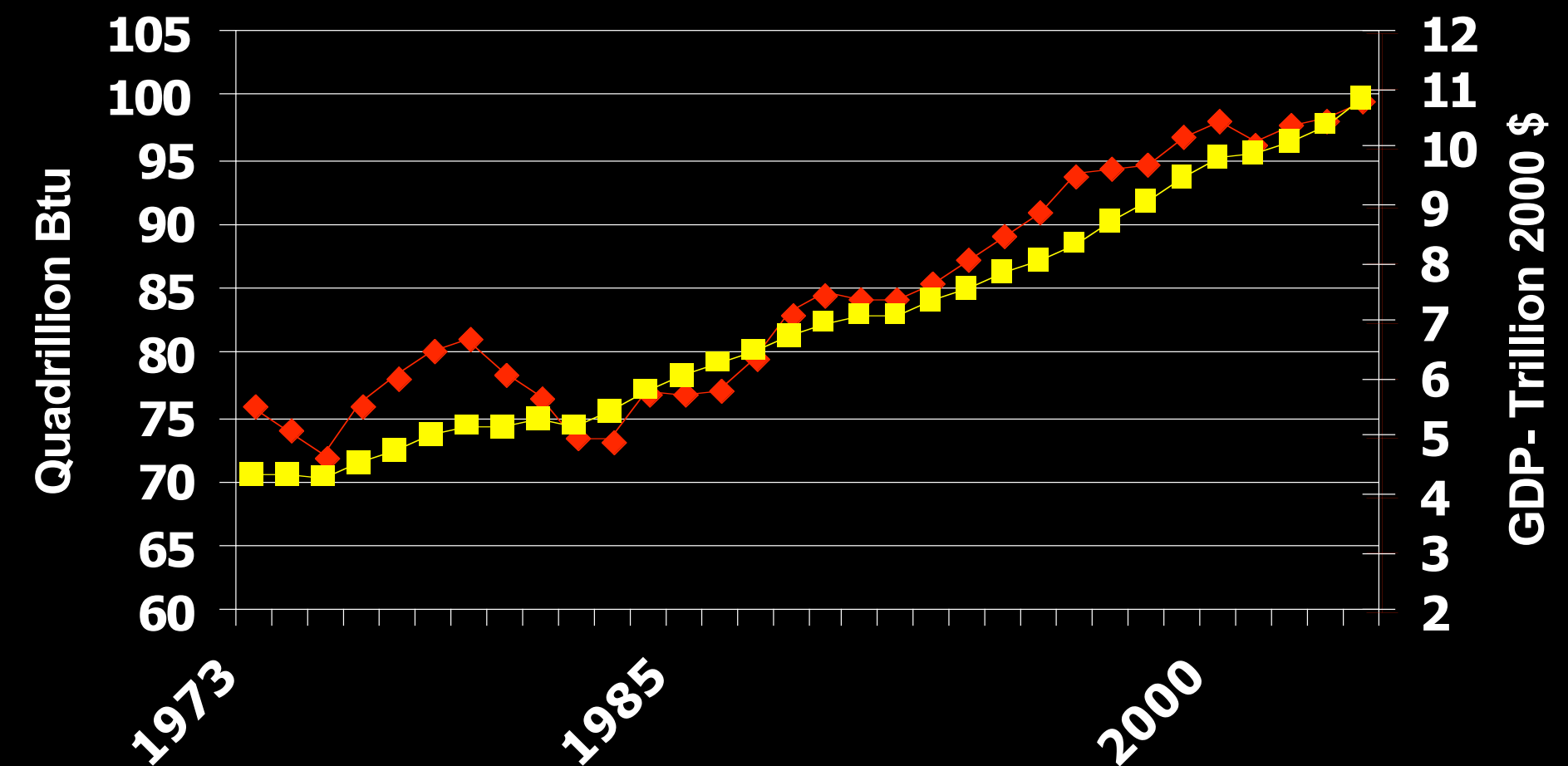
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World Energy Demand



energy questions:

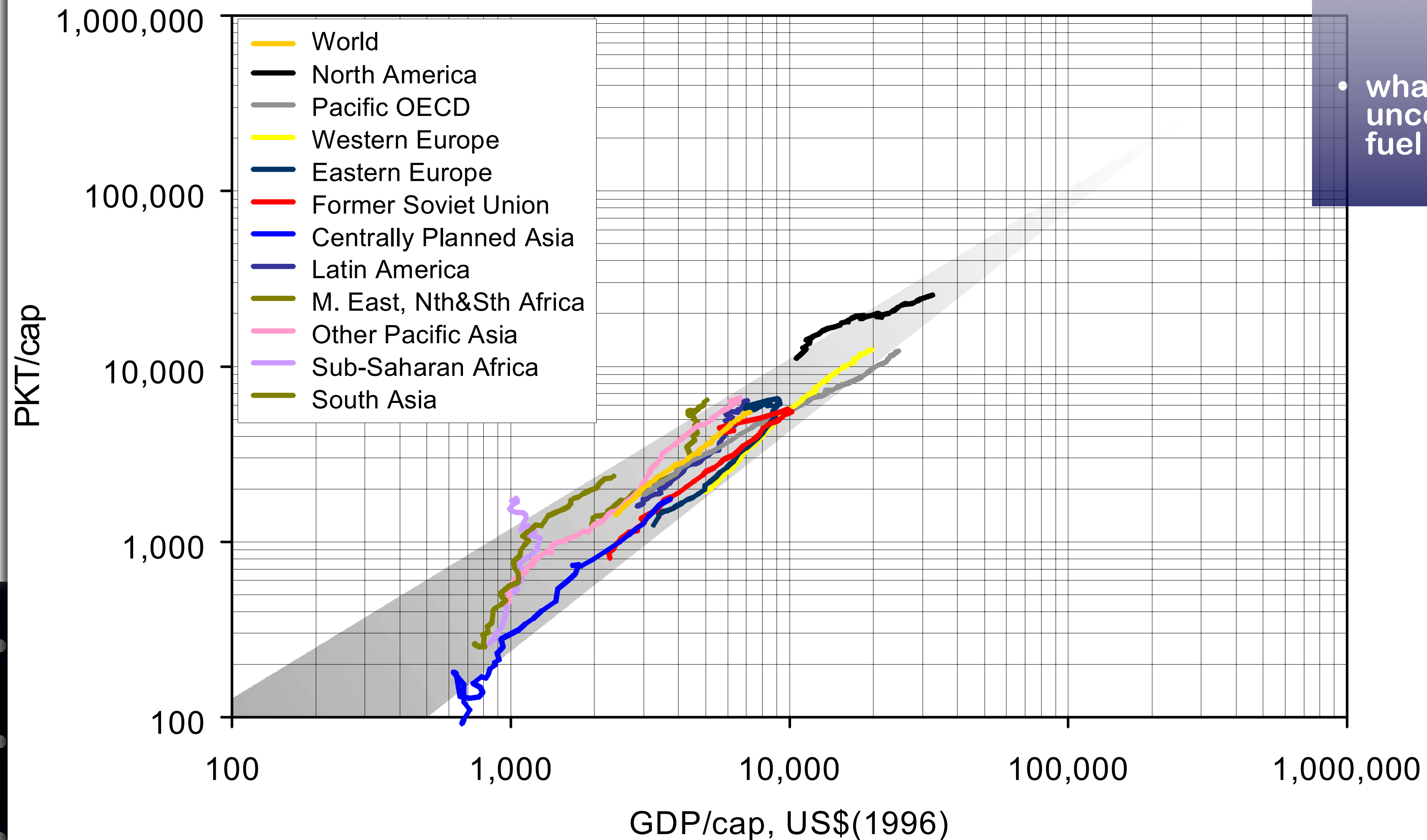
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SOURCE: U.S. Energy Information Administration

- **increasing energy demand**
 - developing nations: China & India
- **rising cost of oil & gas**
 - & low cost of coal
- **huge global reserves of coal**
 - & unconventional heavy oil

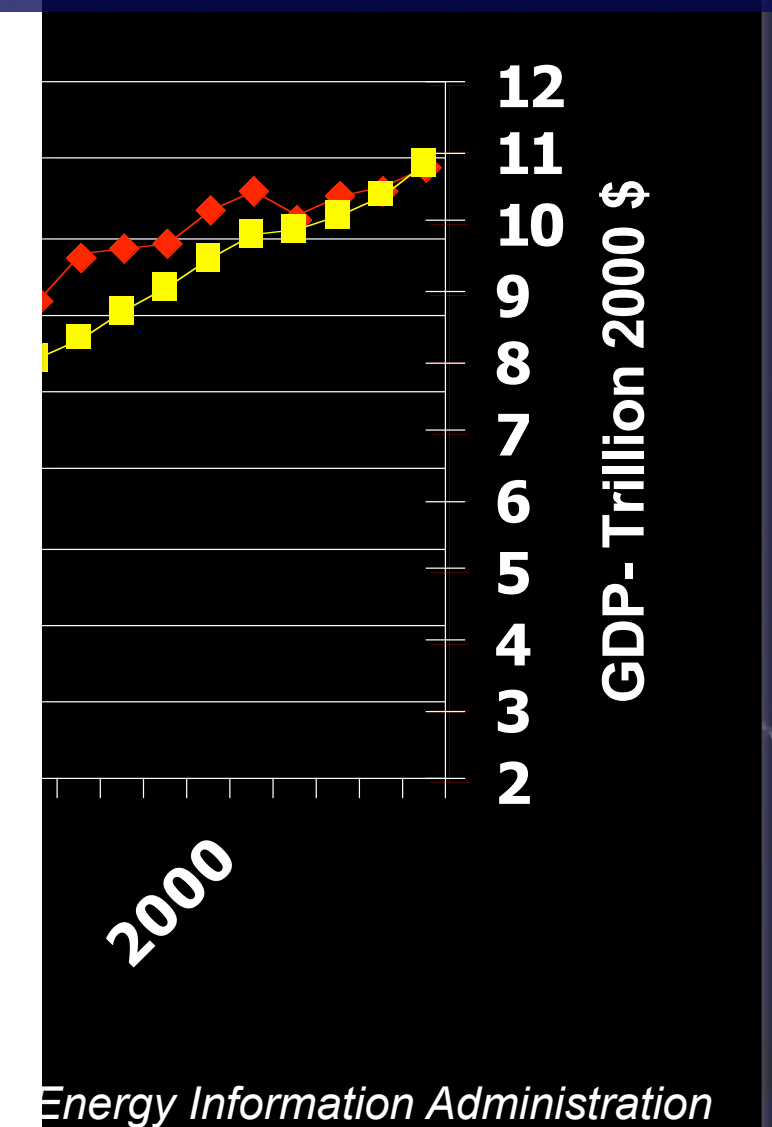
Economic growth brings more, faster travel



energy questions:

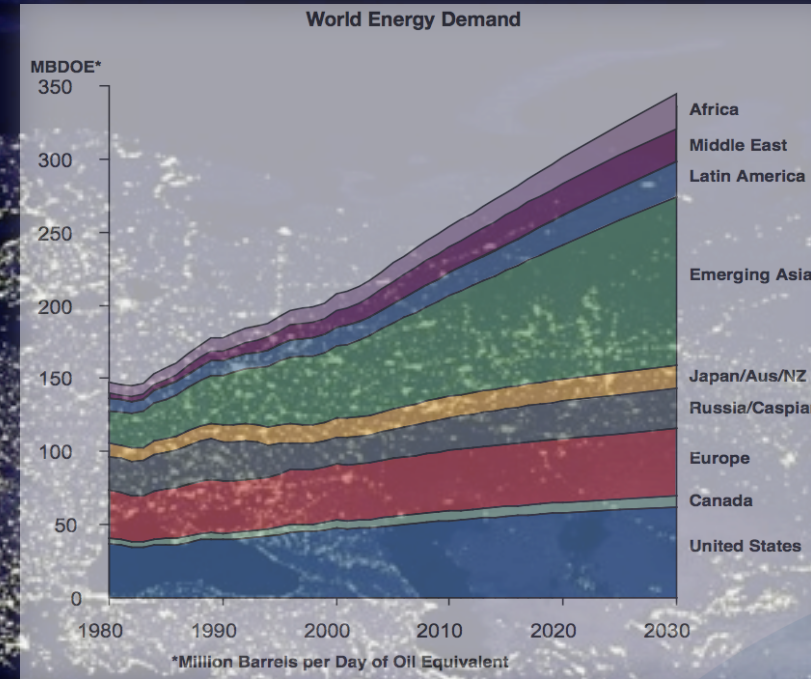
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Source: Schäfer (2005)

“The Growing Storm”



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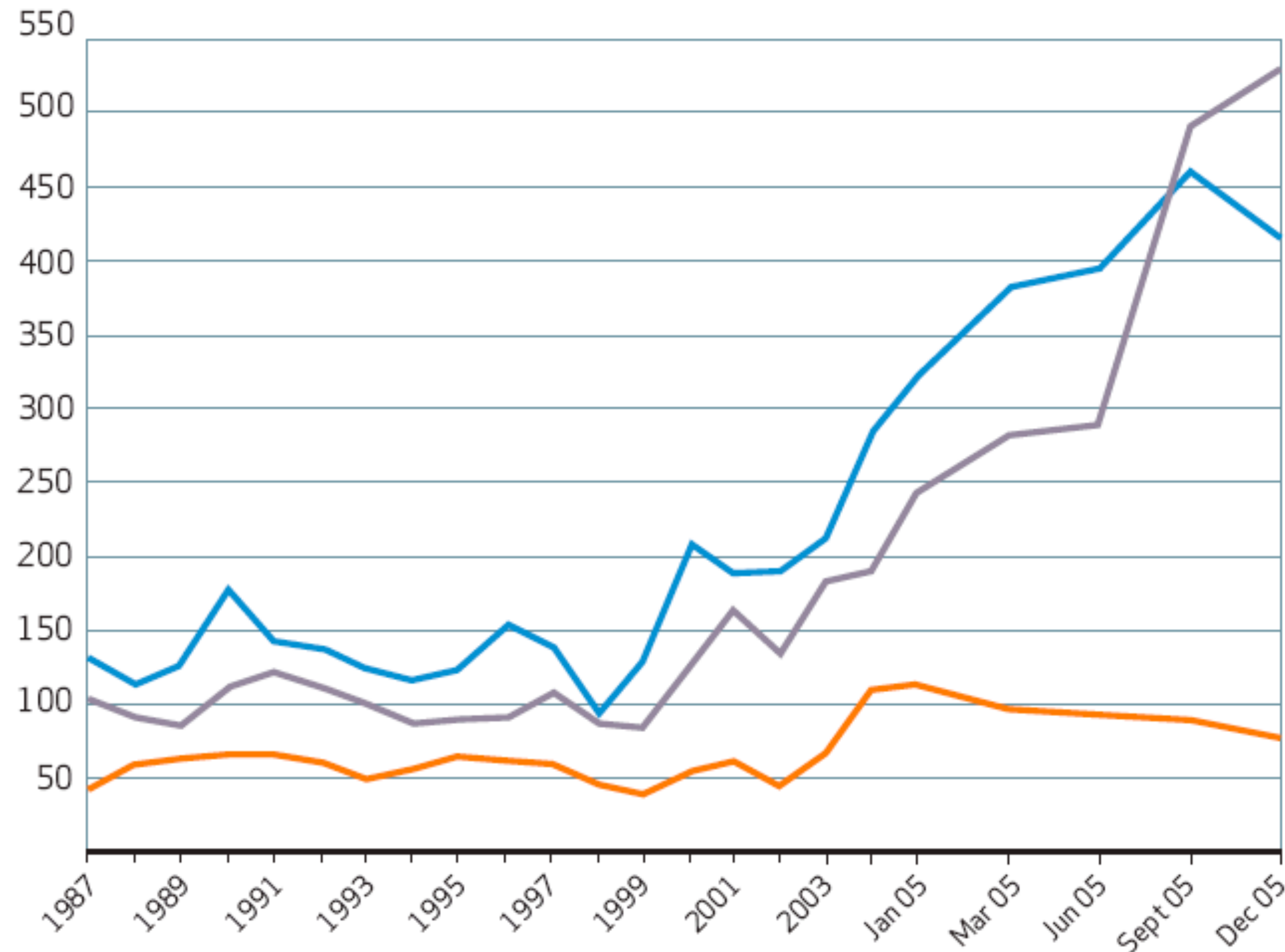
“The G

- increases
- rising c &
- huge gl & unconventional heavy oil

Energy Price Trends (US\$ per tonne of oil equivalent)

Oil
Gas
Coal

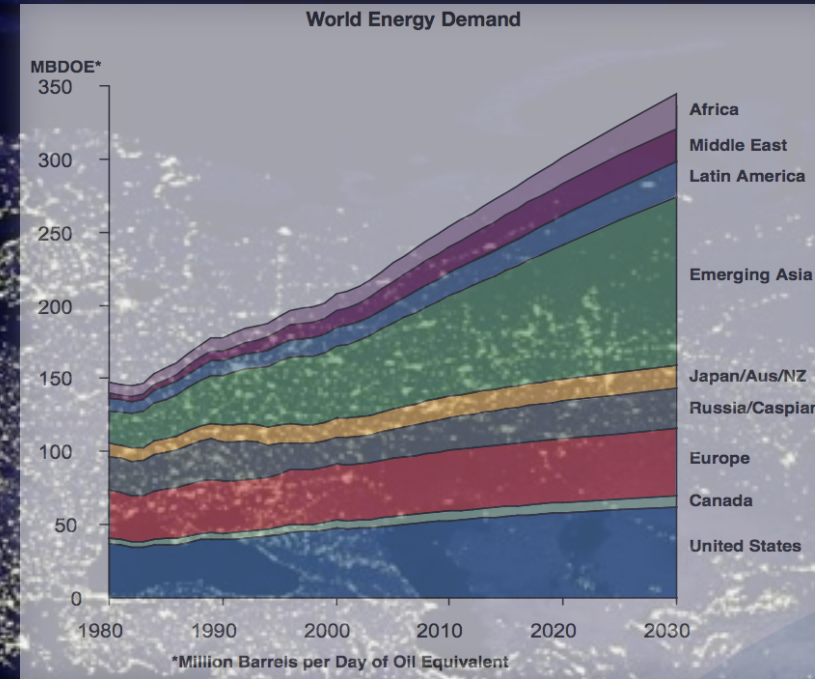
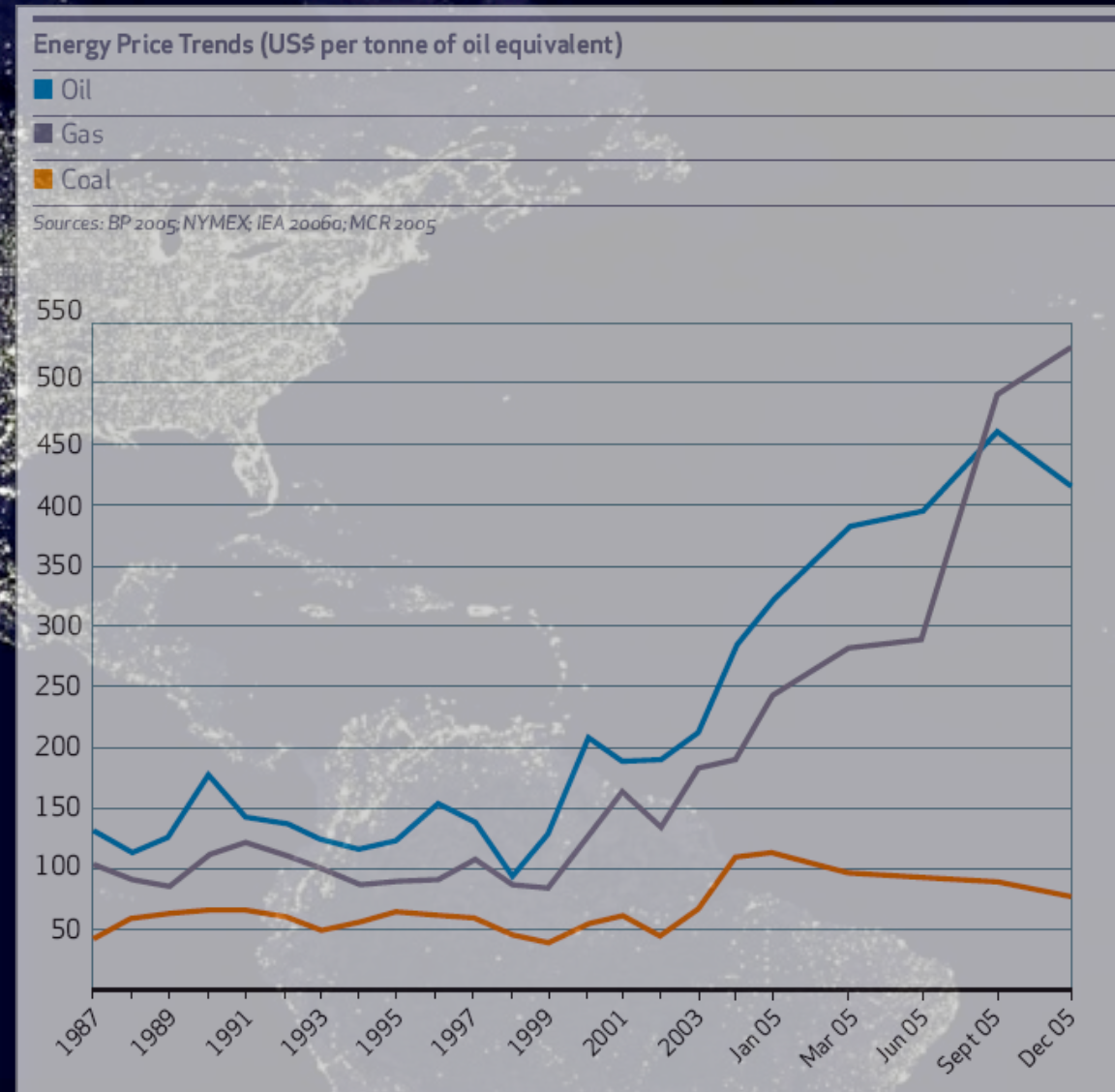
Sources: BP 2005; NYMEX; IEA 2006a; MCR 2005



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“The Growing Storm”

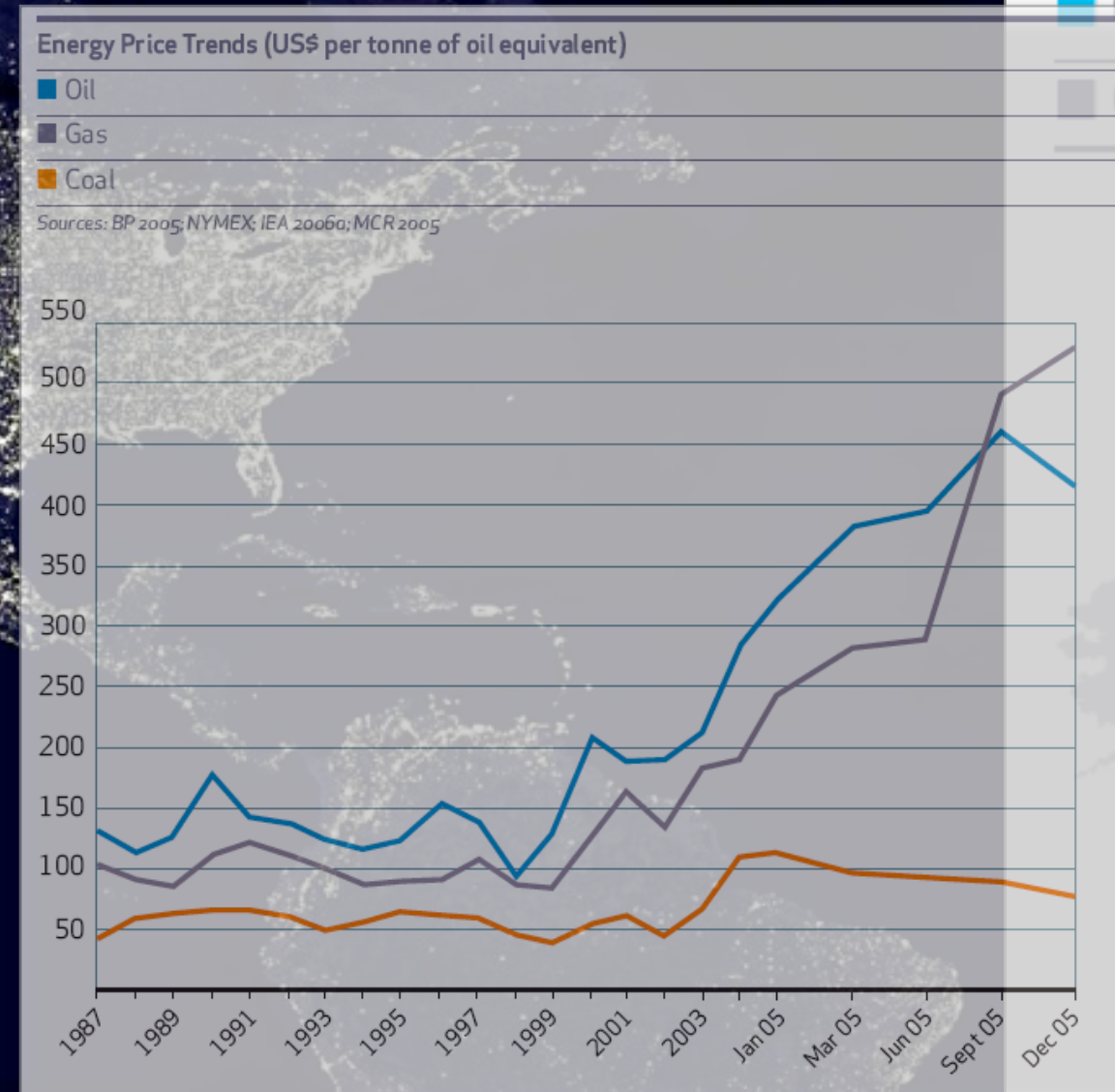


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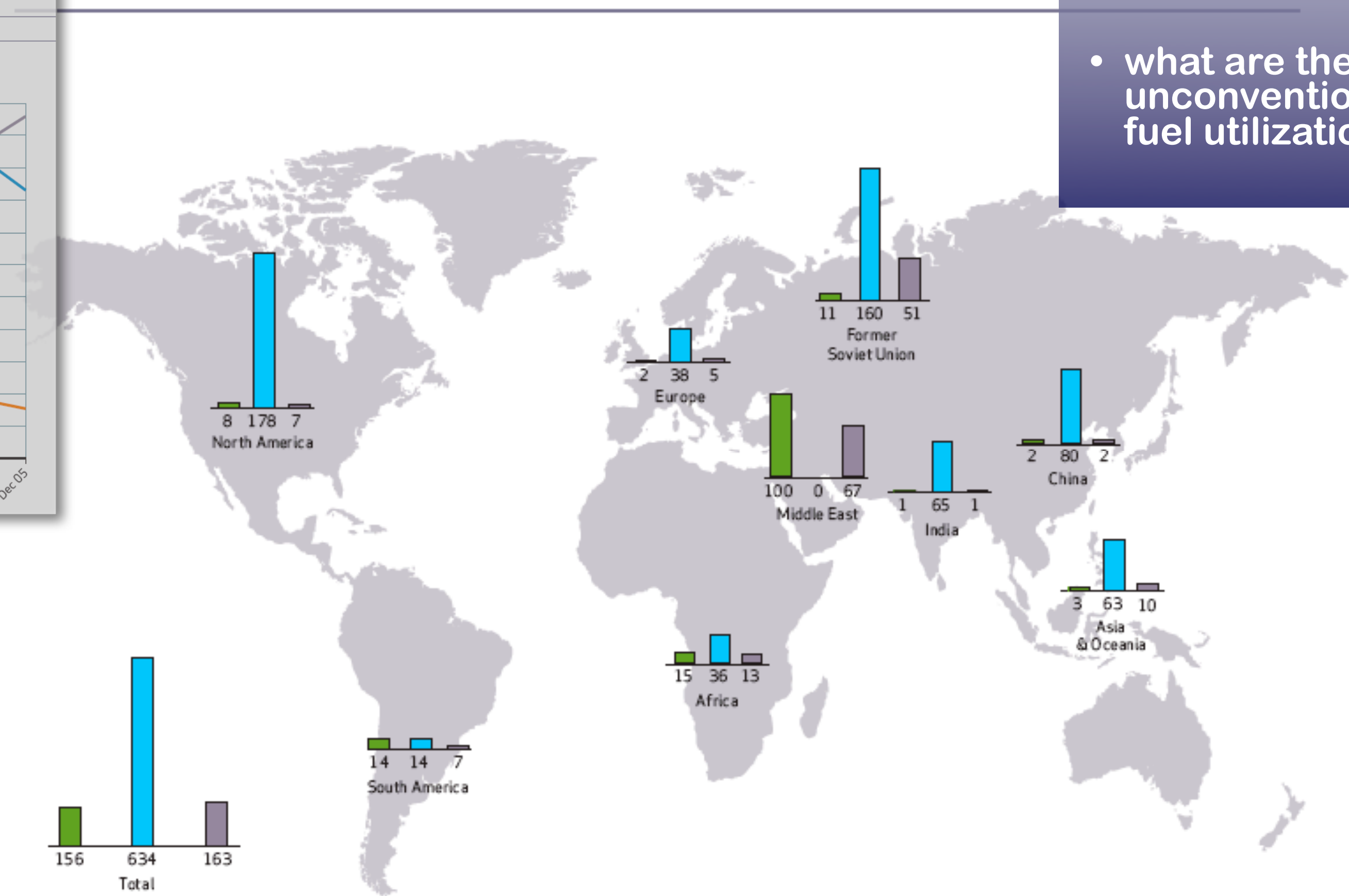
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“The Growing Storm”



Oil
Coal
Gas



* Values below 0.5 Gtoe have been rounded down to 0

Sources: BP and World Energy Council

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- increasing energy demand - developing regions
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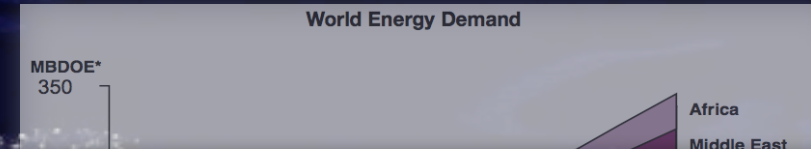
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Gas
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Oil
Coal
Gas

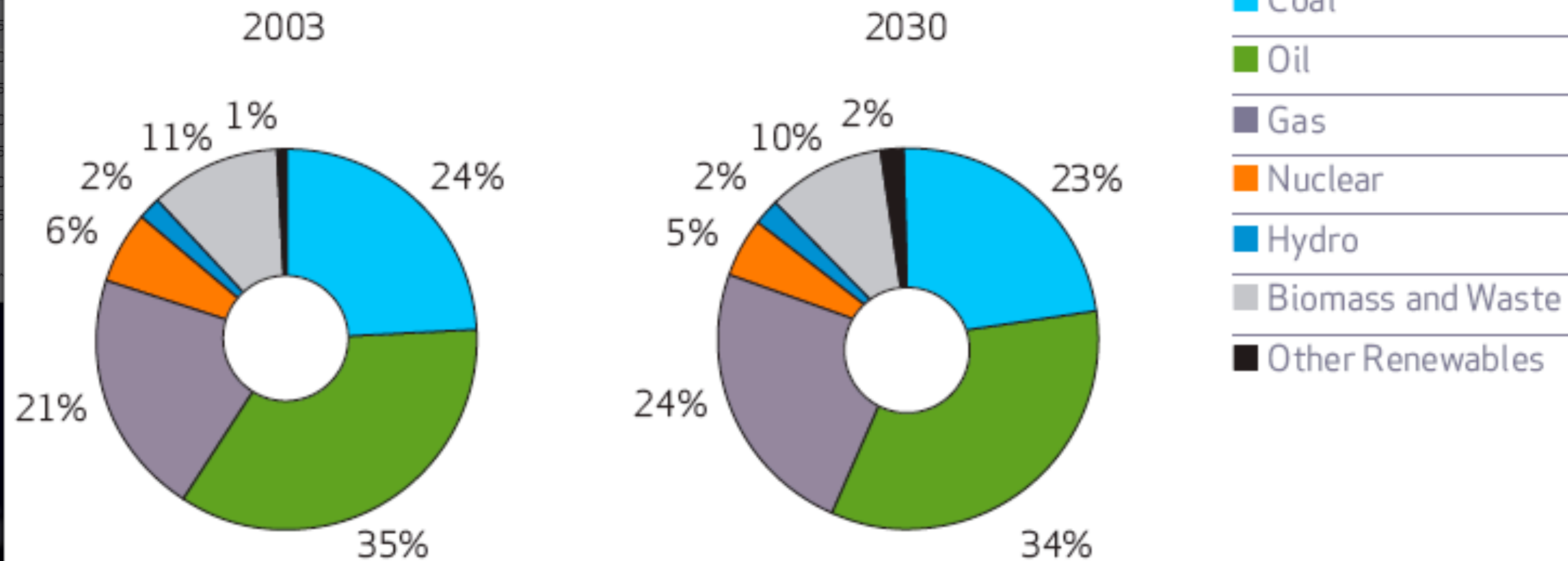


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Total World Primary Energy Consumption (% by Fuel)



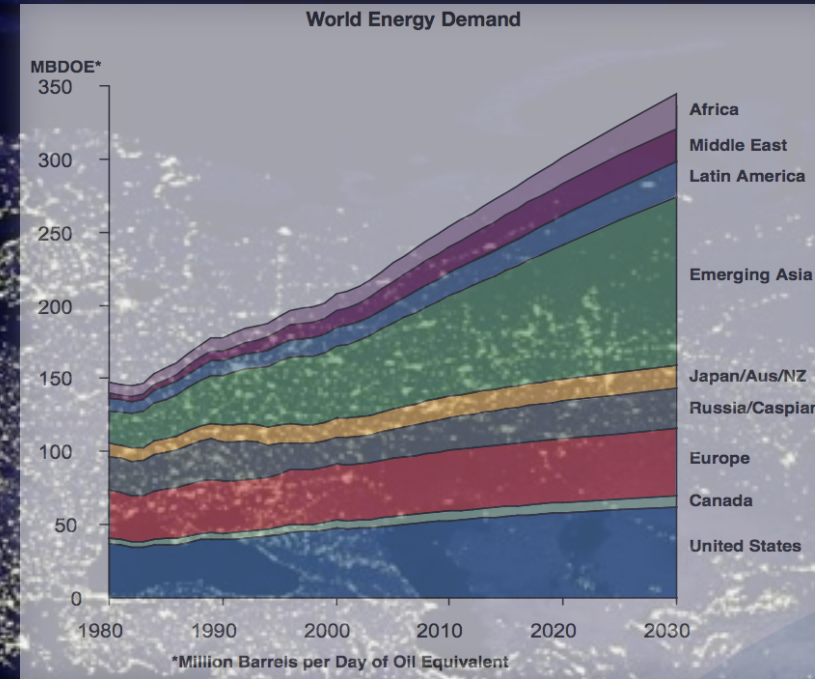
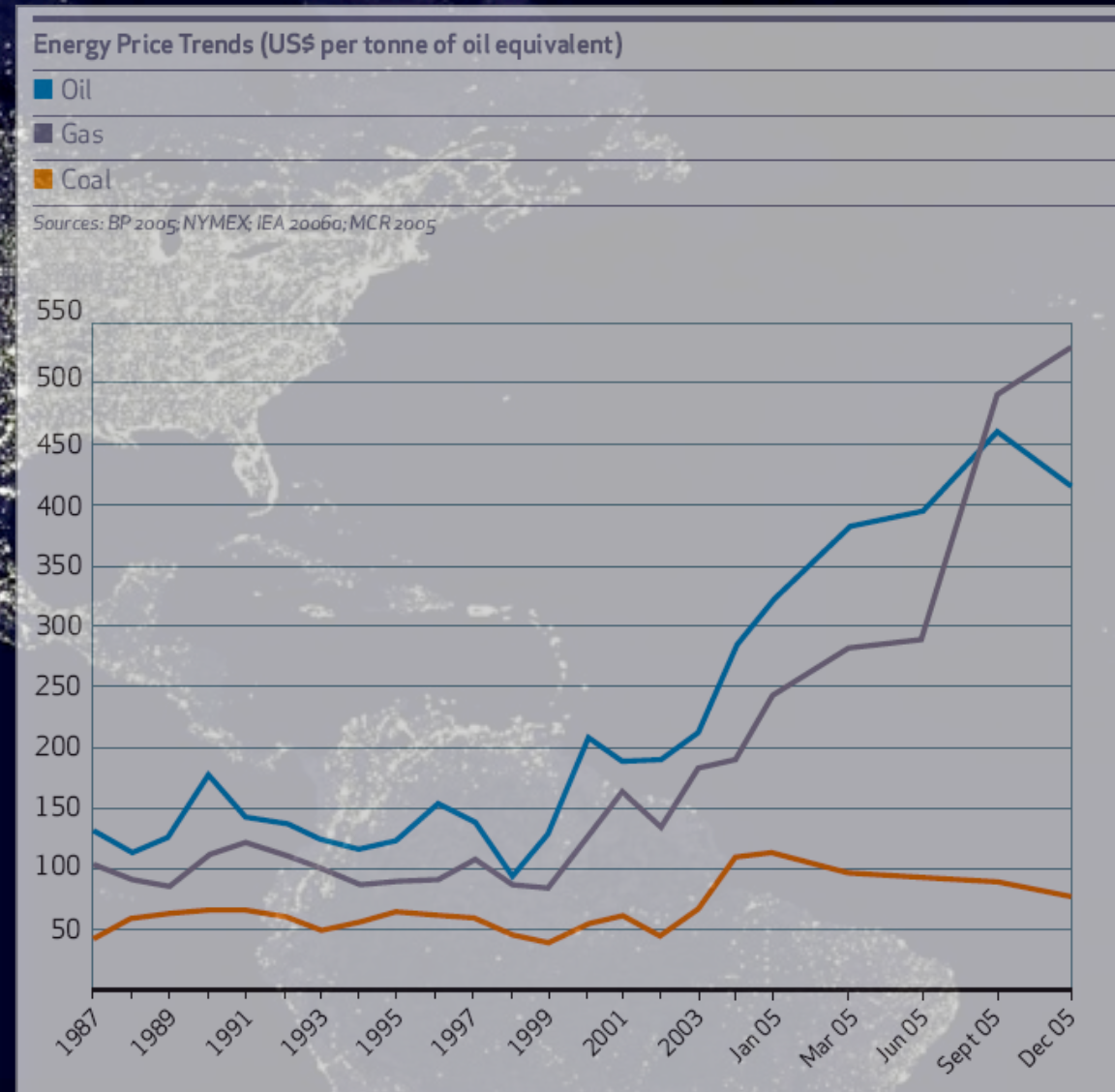
Source: IEA 2005a

* Values below 0.5 Gtoe have been rounded down to 0

Sources: BP and World Energy Council

• huge global reserves
& unconventional

“The Growing Storm”



energy questions:

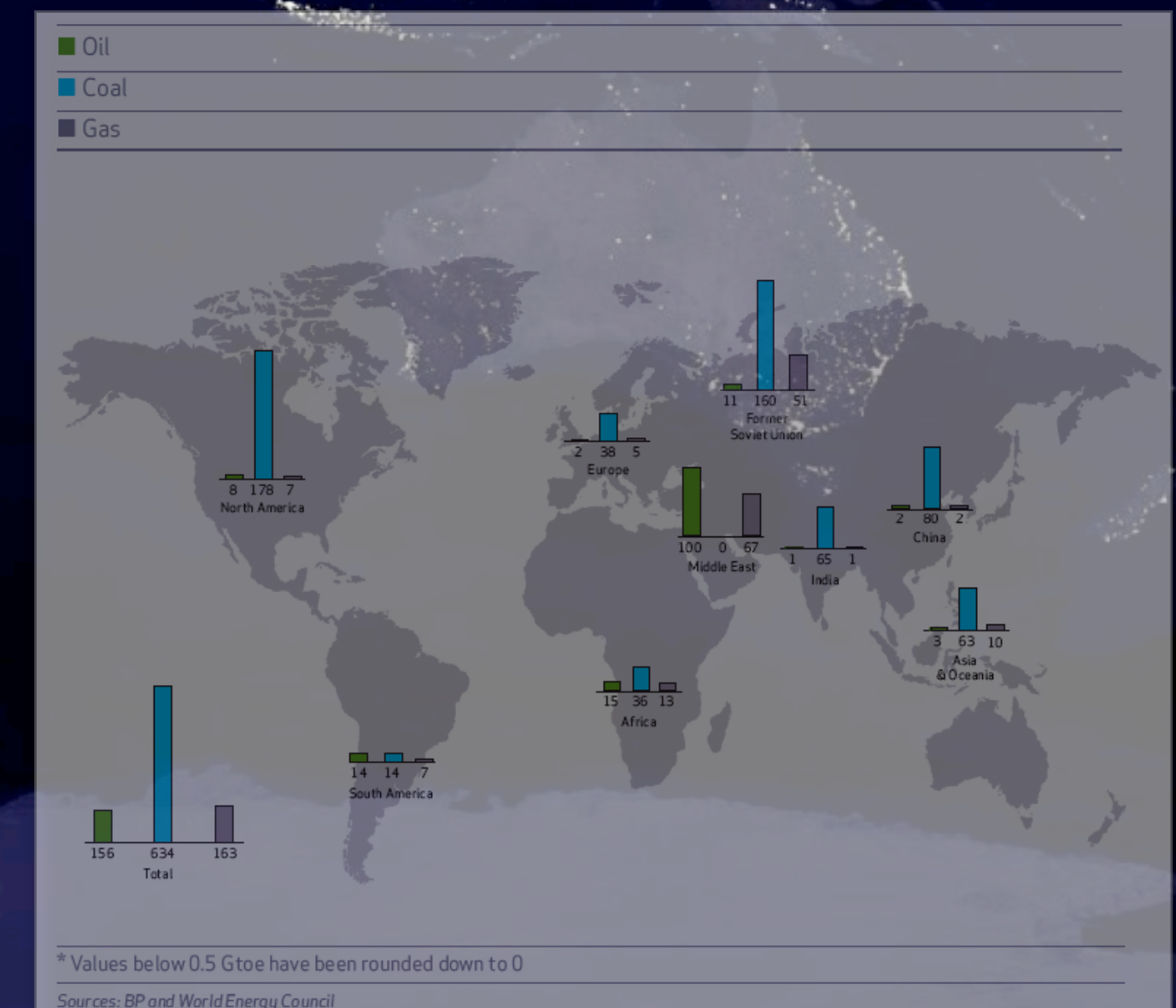
- what is the future for energy sources?

80% of global source of energy will be fossil

- what are the drivers for unconventional (heavy) fuel utilization?

**- low cost
- wide-spread abundance**

- **increasing energy demand**
 - developing nations: China & India
- **rising cost of oil & gas** & **low cost of coal**
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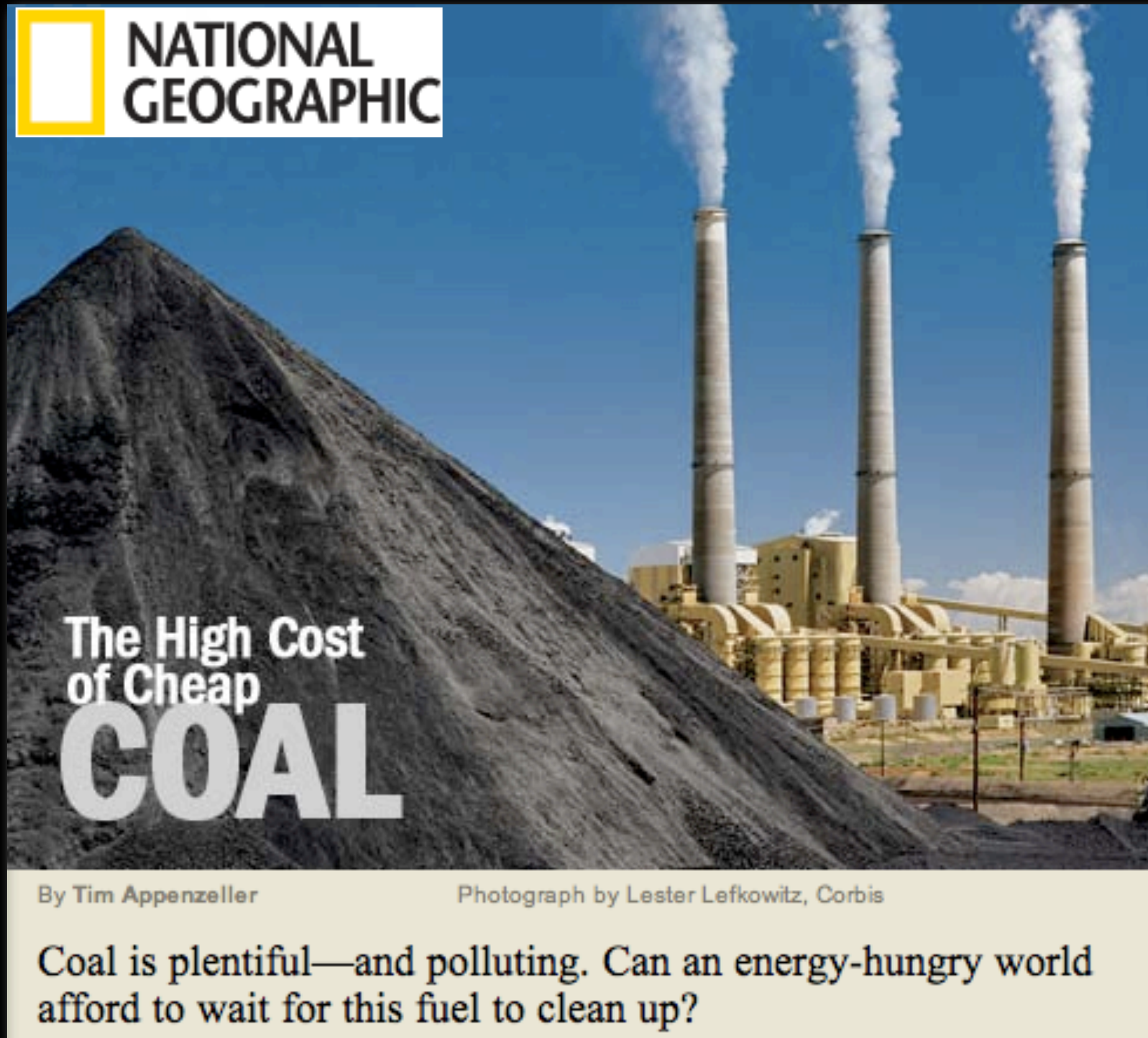


the issues with fossil

the issues with fossil

fossil fuel utilization
question:

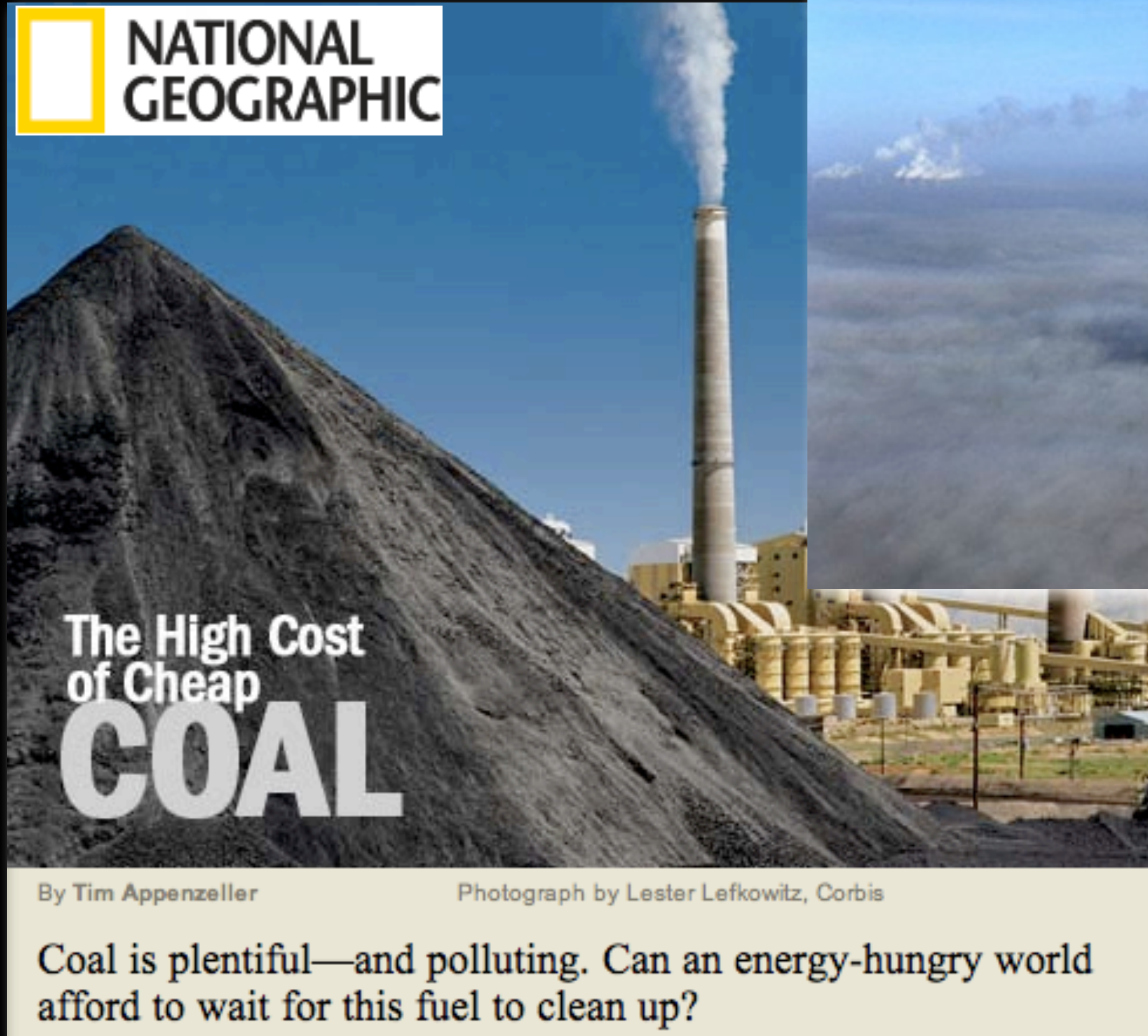
- what are the issues with fossil fuel utilization?



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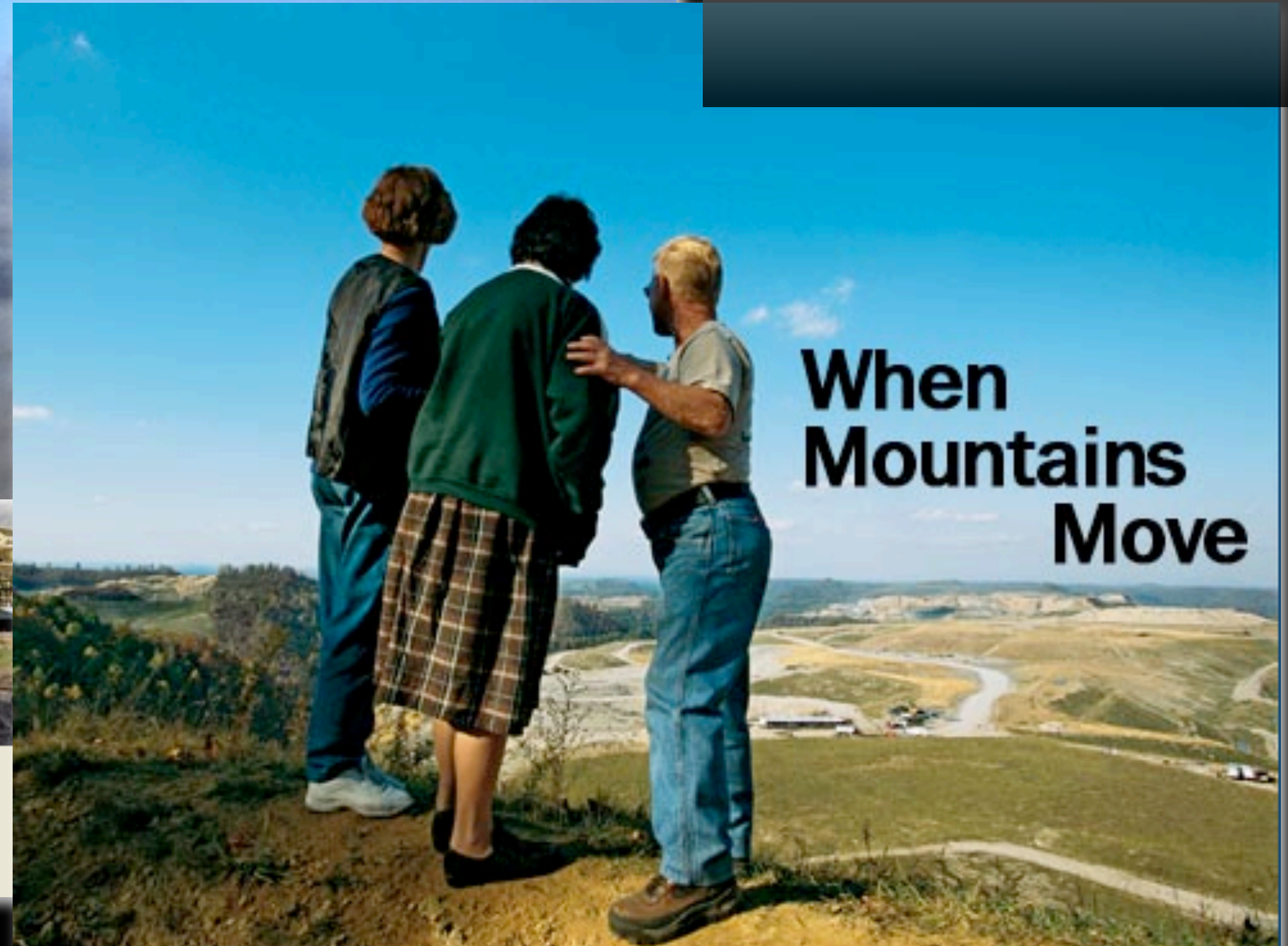


The High Cost of Cheap COAL

By Tim Appenzeller

Photograph by Lester Lefkowitz, Corbis

Coal is plentiful—and polluting. Can an energy-hungry world afford to wait for this fuel to clean up?



When Mountains Move

By John G. Mitchell

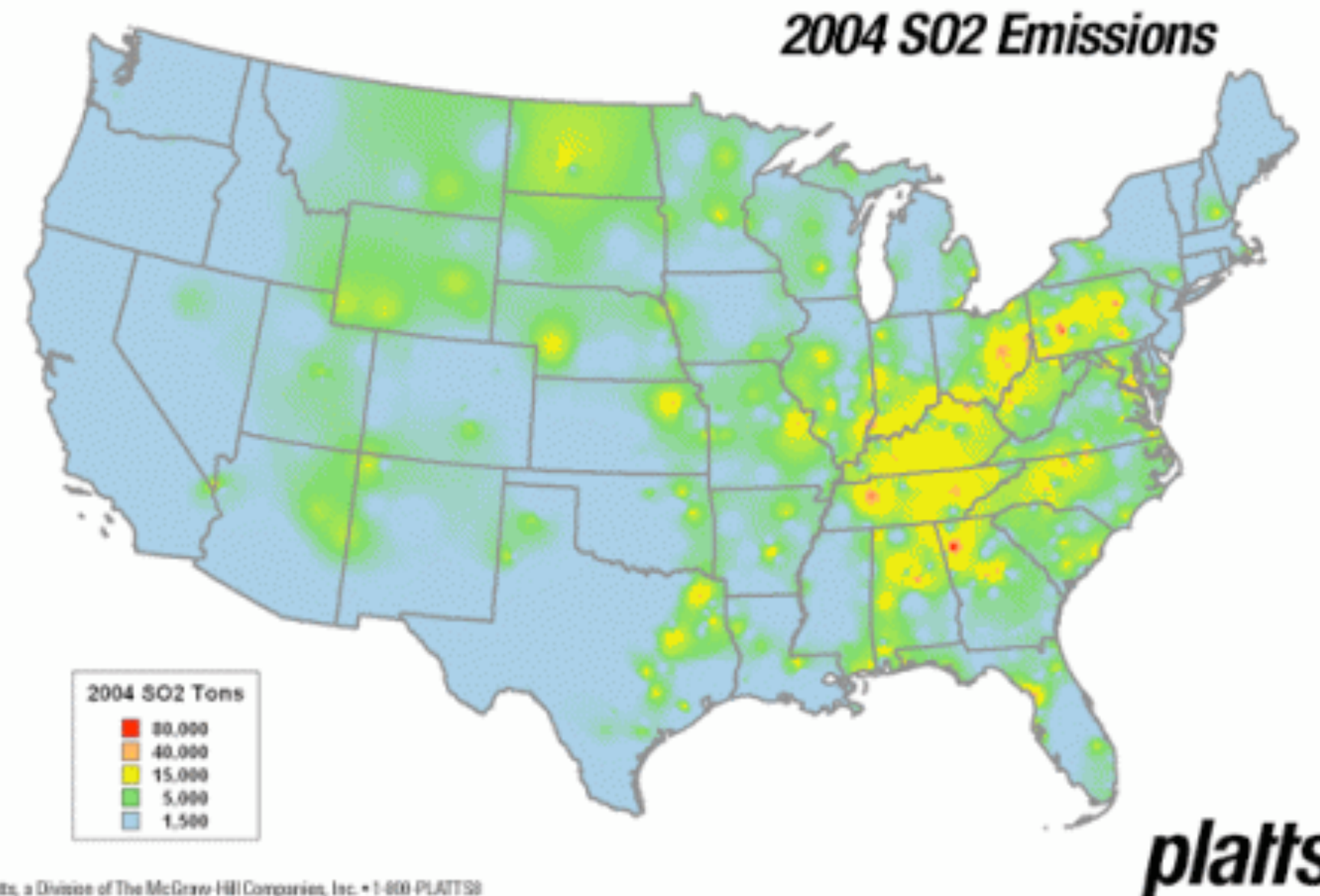
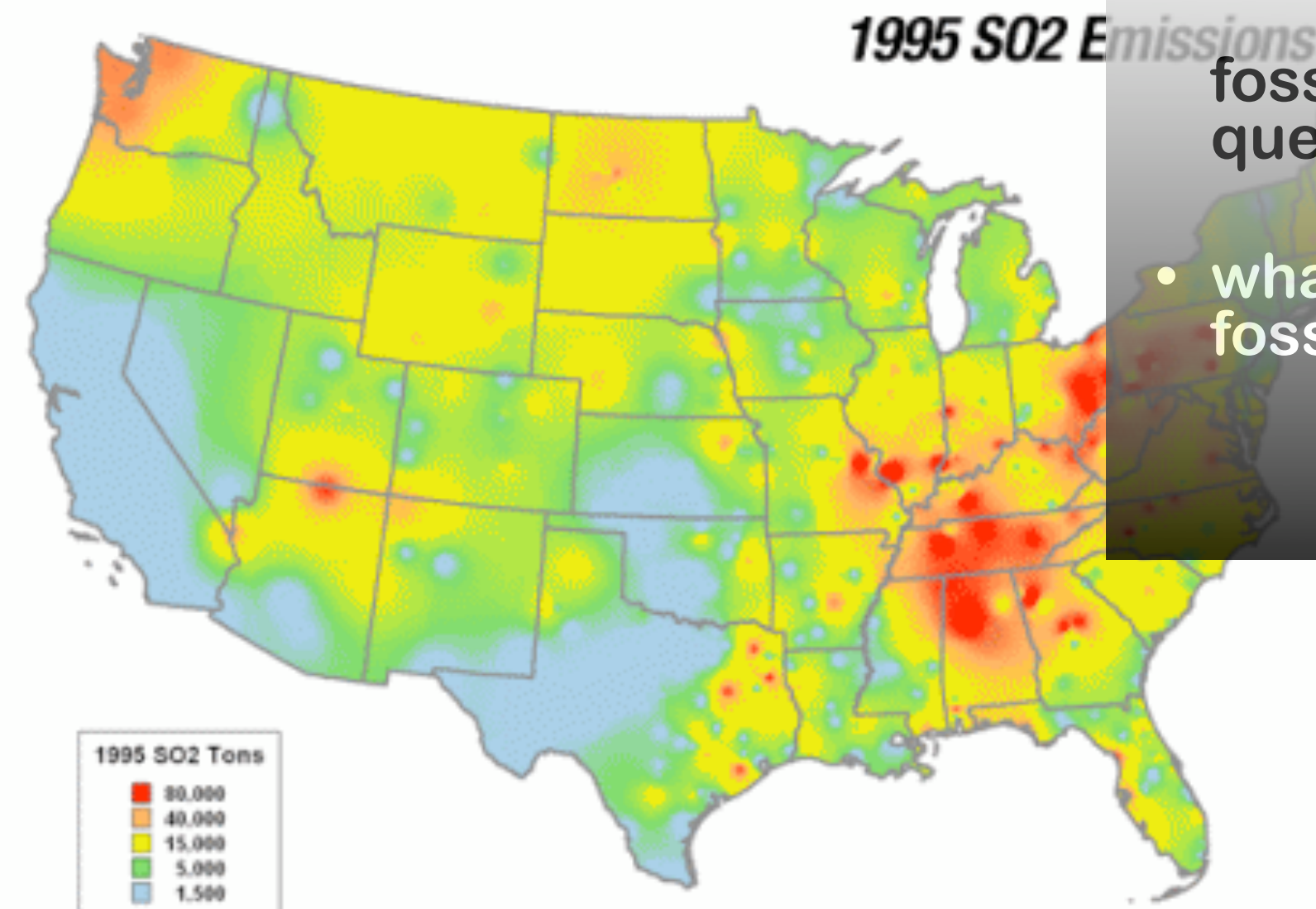
Photographs by Melissa Farlow

The quest for Appalachian coal has led to mountaintop removal, a process that's been called "strip mining on steroids."

the issues with fossil

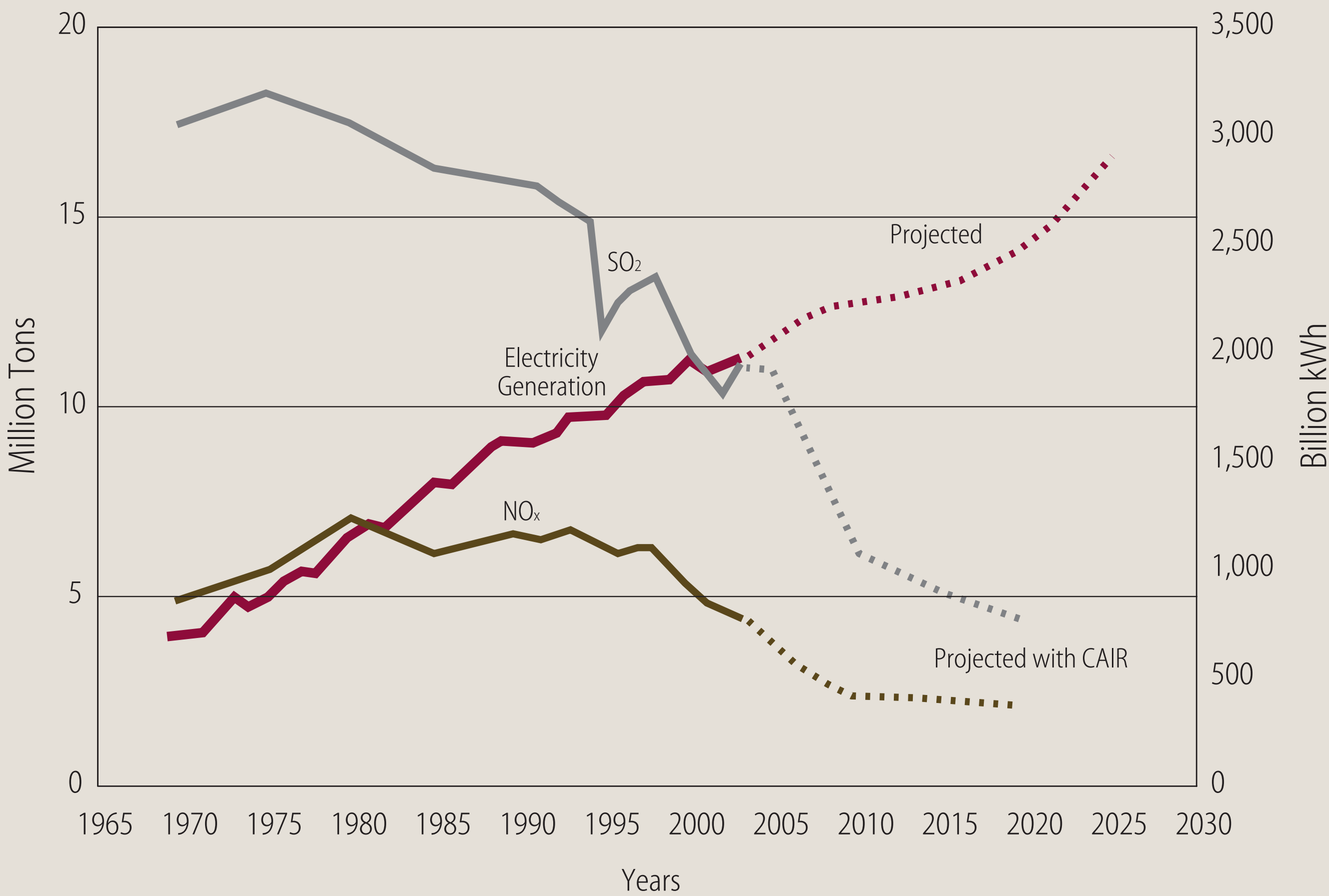
fossil fuel utilization
question:

- what are the issues with fossil fuel utilization?



the issues with fossil

Figure A-3.D.1 Achieved and Projected SO₂ and NO_x Emissions Reductions and Growth in U.S. Electricity Generation



fossil fuel utilization question:

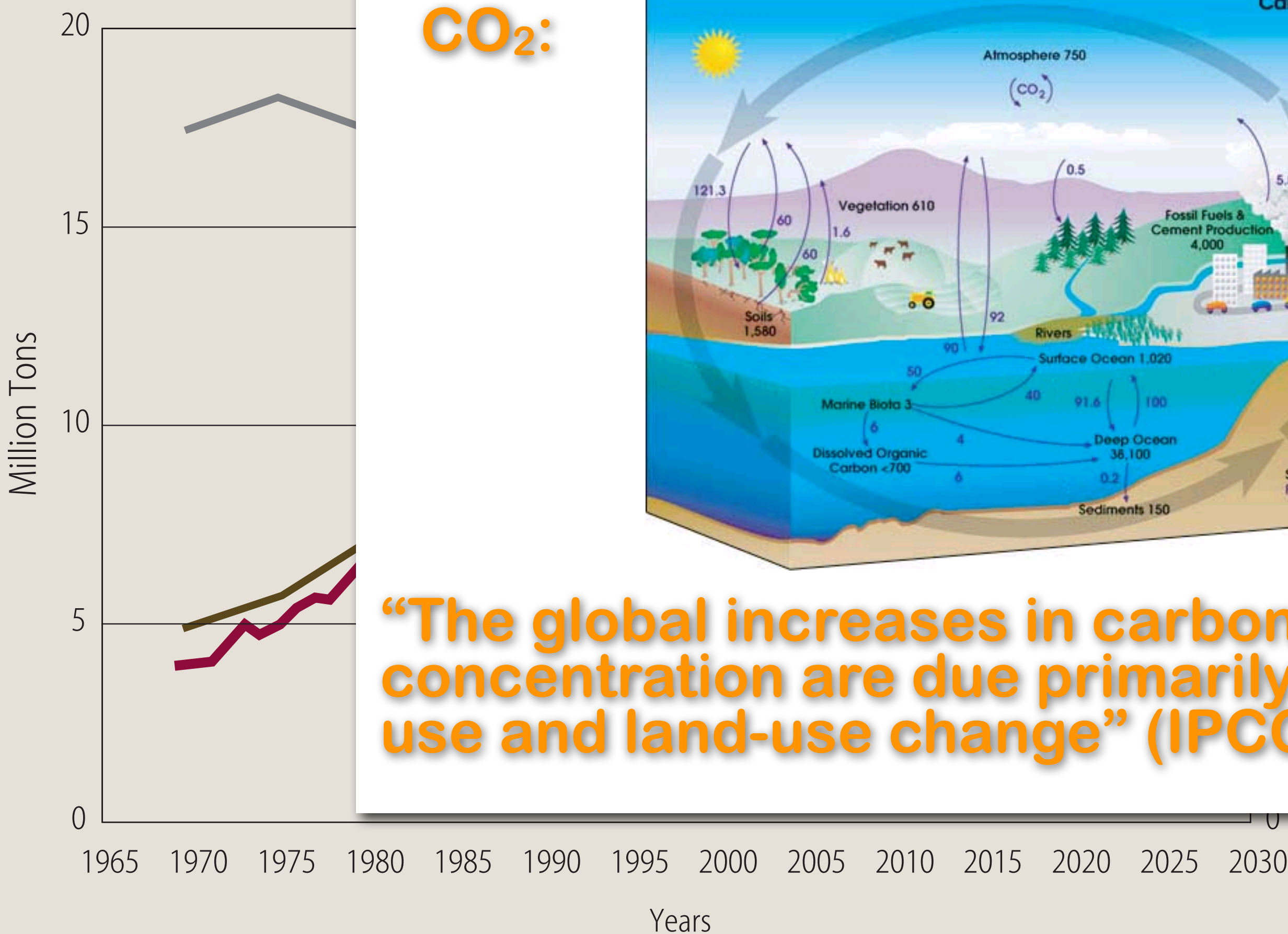
- what are the issues with fossil fuel utilization?

Emissions

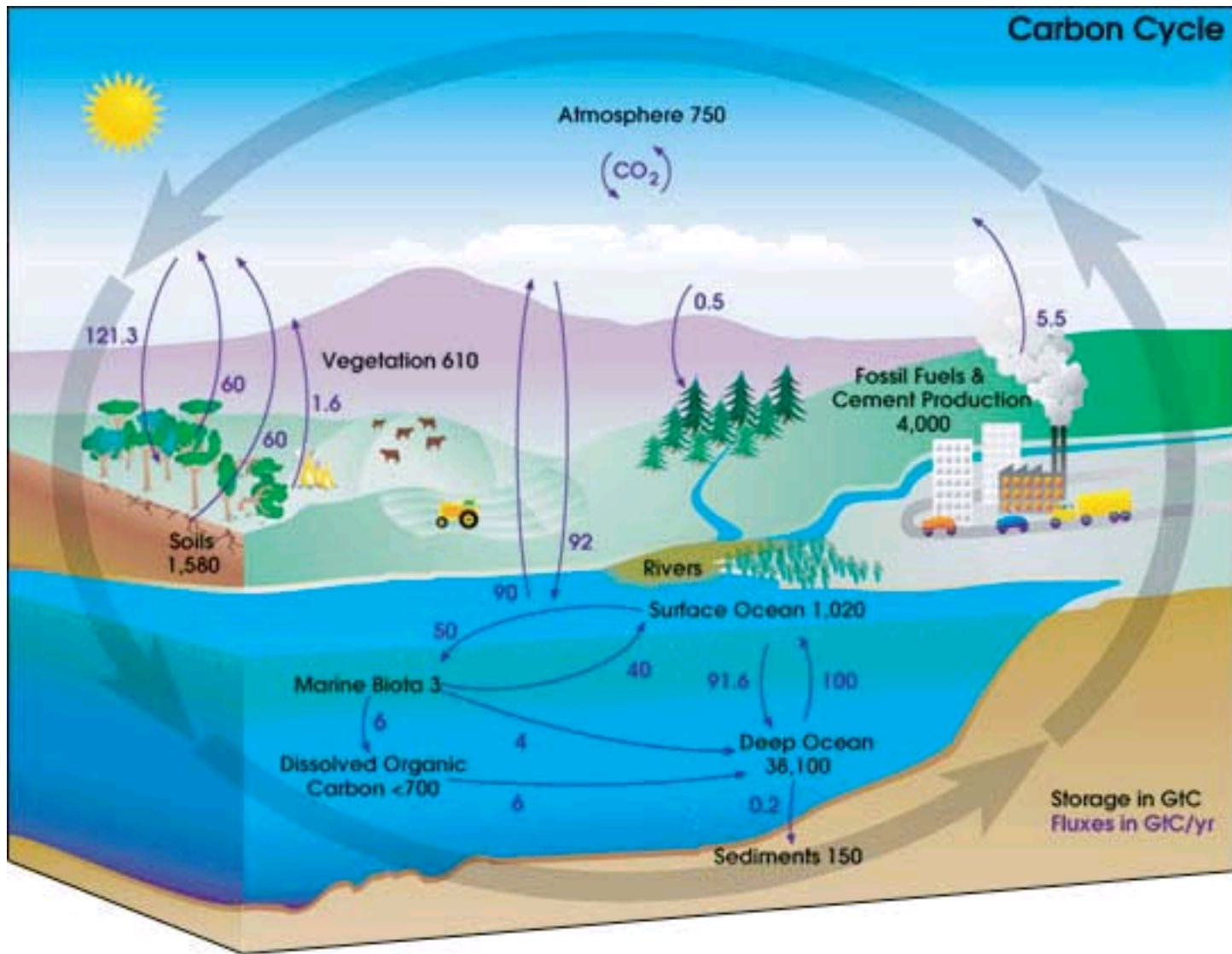
platts

the issues with fossil

Figure A-3.D.1 Achieved and Projected SO₂ and NO_x Emissions Reductions and G



CO₂:



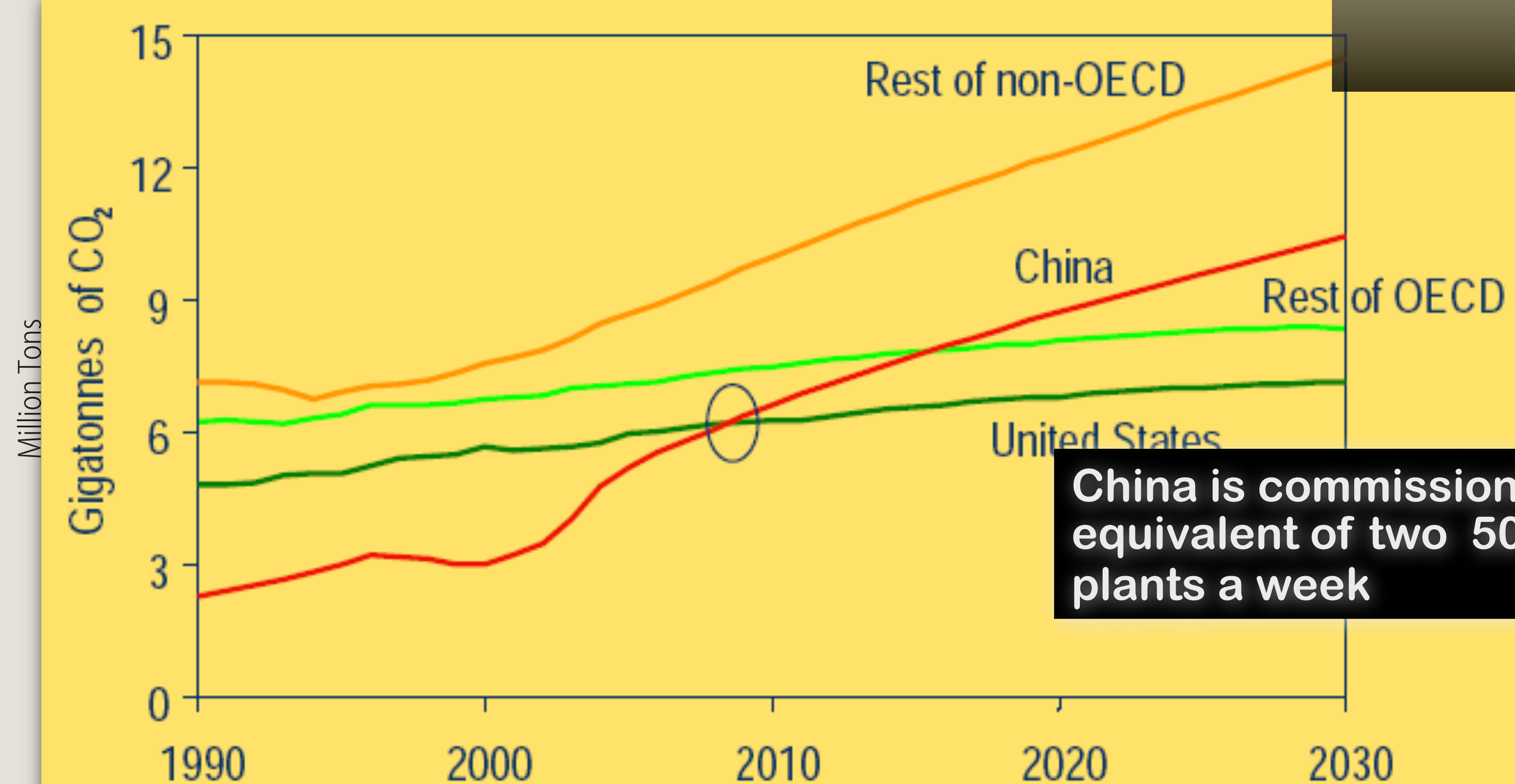
“The global increases in carbon dioxide concentration are due primarily to fossil fuel use and land-use change” (IPCC, 2007)

fossil fuel utilization question:

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the issues with fossil

Figure A-3.D.1 Achieved and Projected SO₂ and NO_x Emissions Reductions and Growth in U.S. Electricity Generation



China is commissioning the equivalent of two 500 MW_e plants a week

Source: IEA WEO 2006, prepared by National Mining Association, 2007

1995 SO₂ Emissions

fossil fuel utilization question:

- what are the issues with fossil fuel utilization?

plants

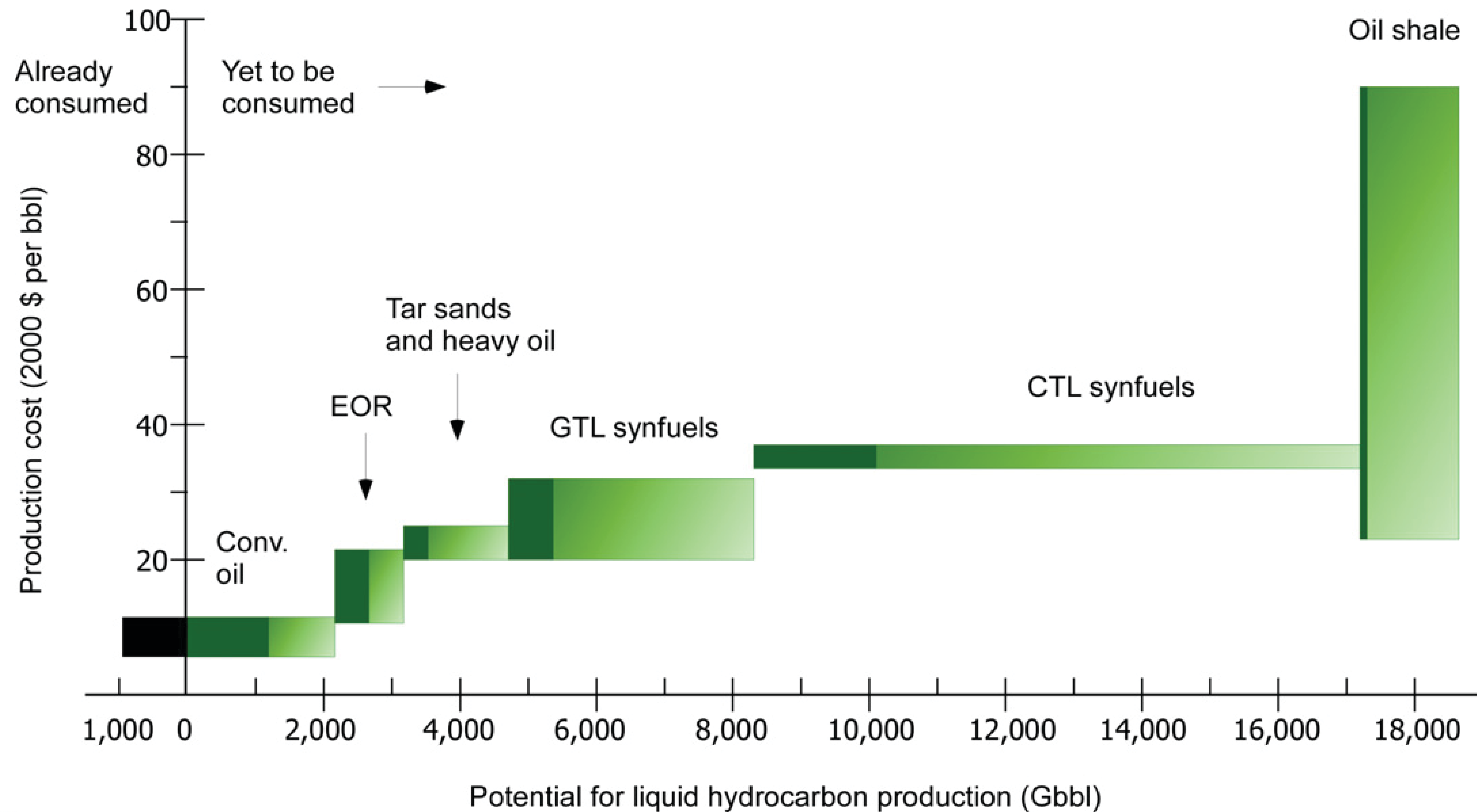
the issues with fossil

fossil fuel utilization
question:

- what are the issues with fossil fuel utilization?
 - safety
 - NO_x, SO_x, Hg
 - CO₂

the size & cost of fossil sources

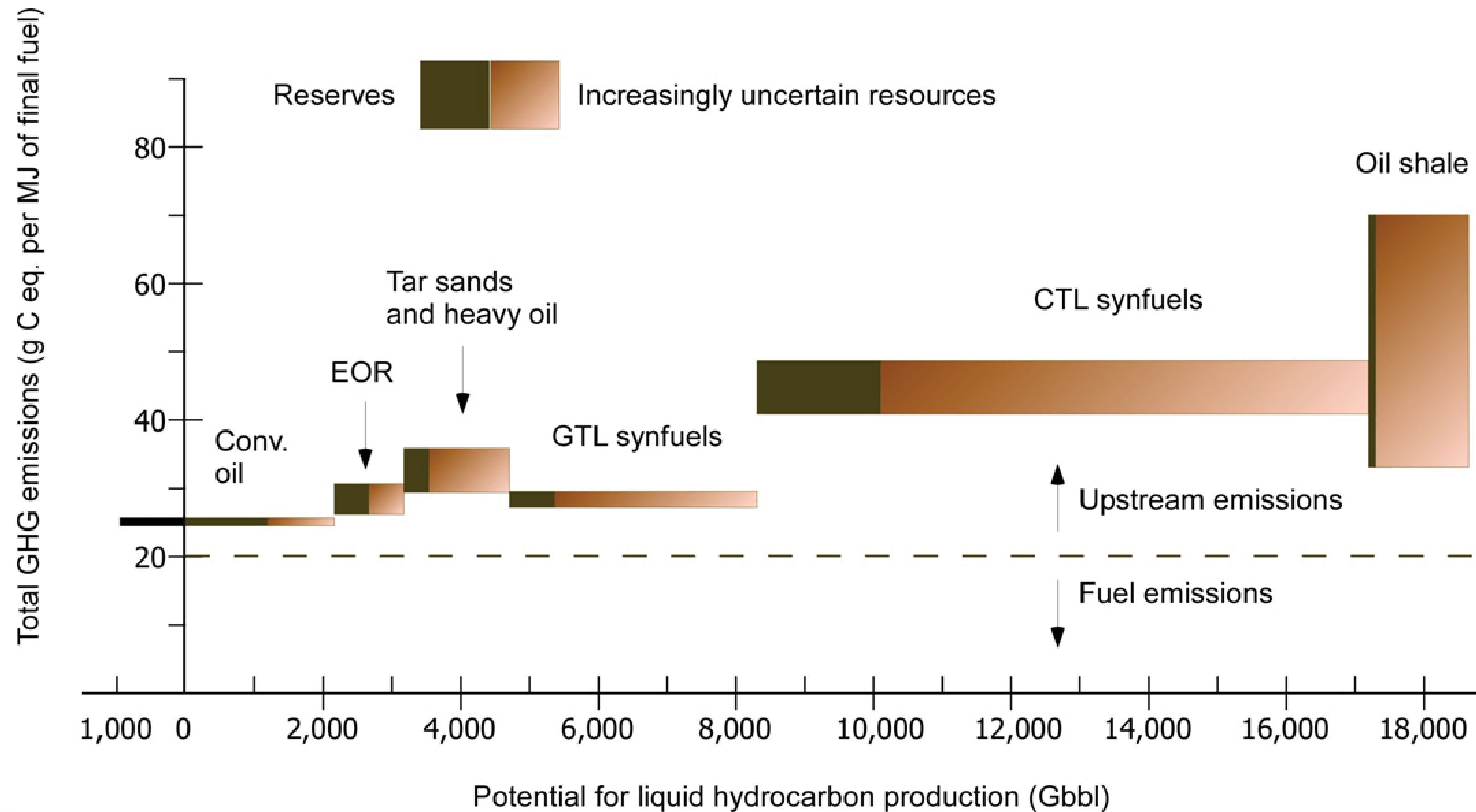
A E Farrell and A R Brandt,
Environ. Res. Lett. 1 (2006) 014004 (6pp)



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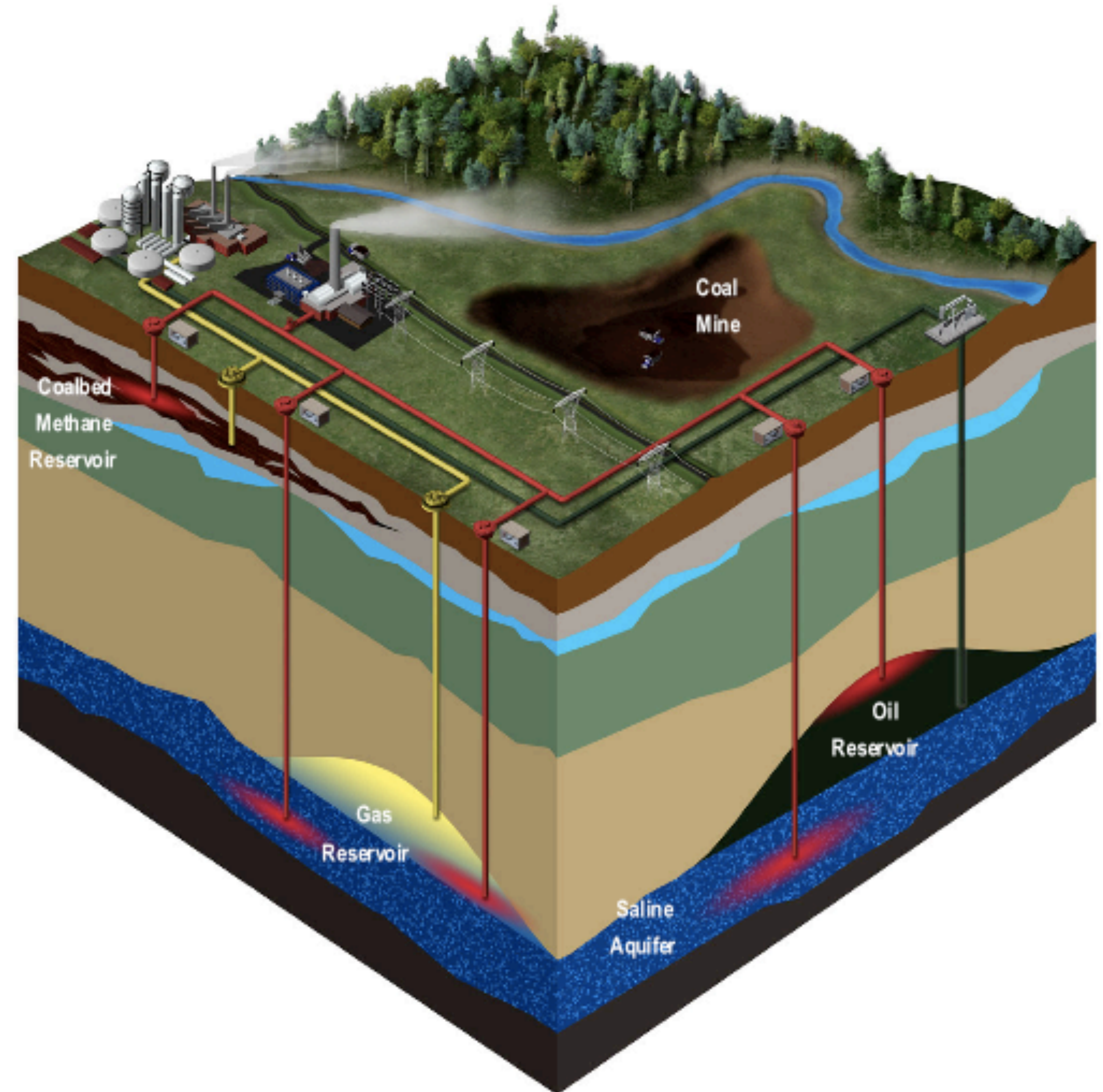
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GHG: carbon capture & storage (CCS)

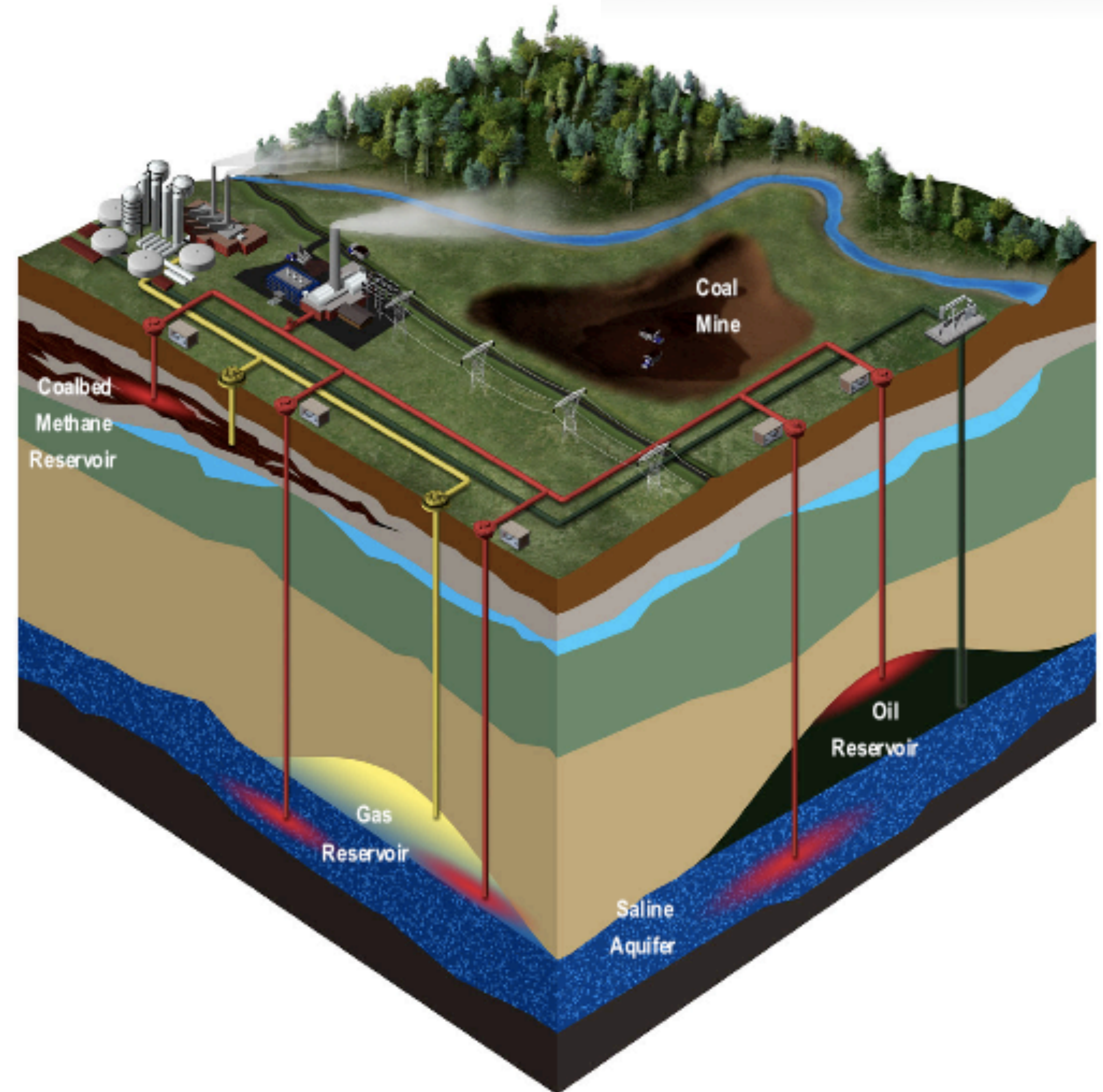
- **CO₂ injection for:**
 - enhanced coalbed methane recovery
 - enhanced oil recovery
- **acid gas injection**
- **deep disposal**



GHG: carbon capture & storage (CCS)

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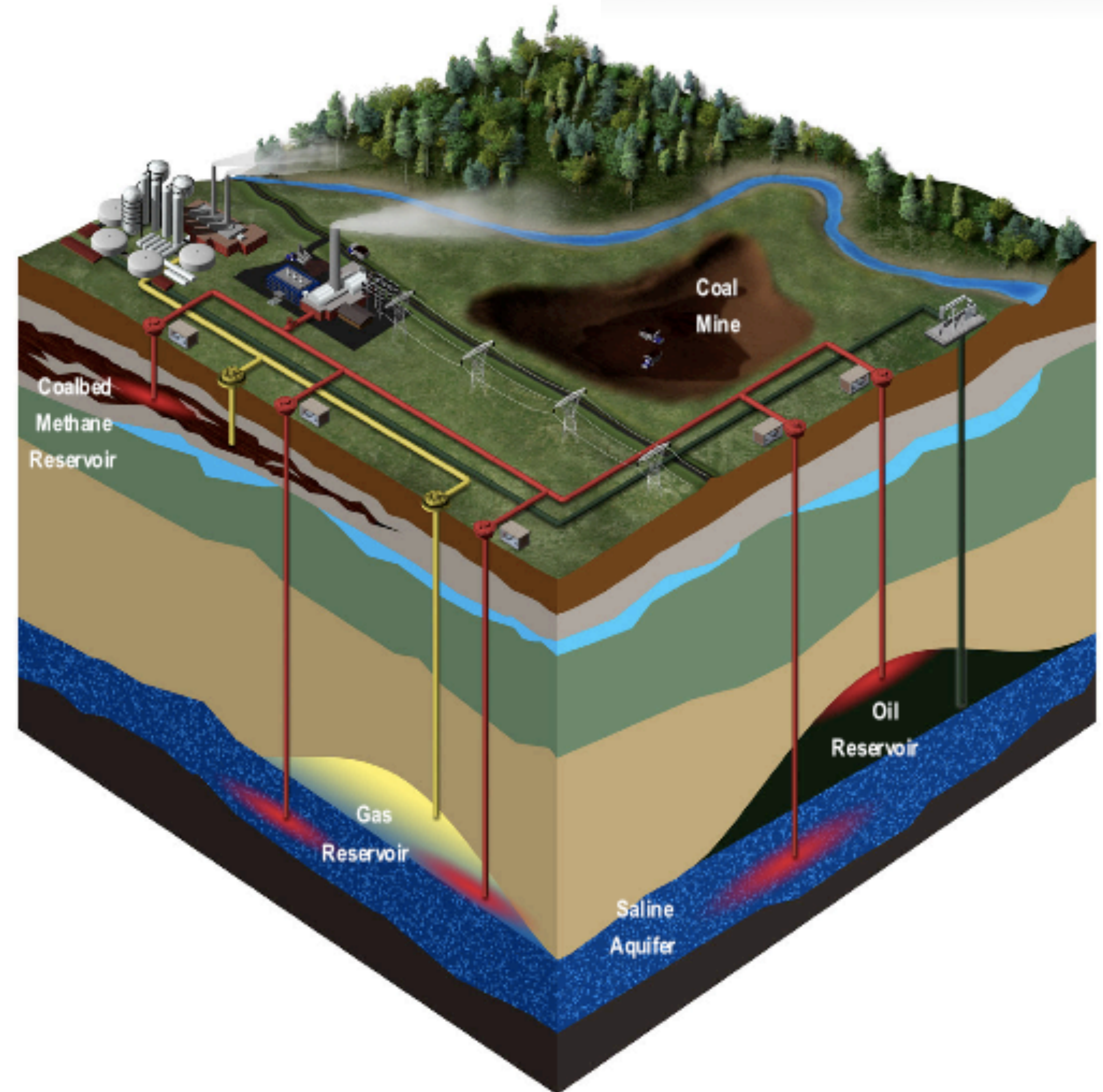
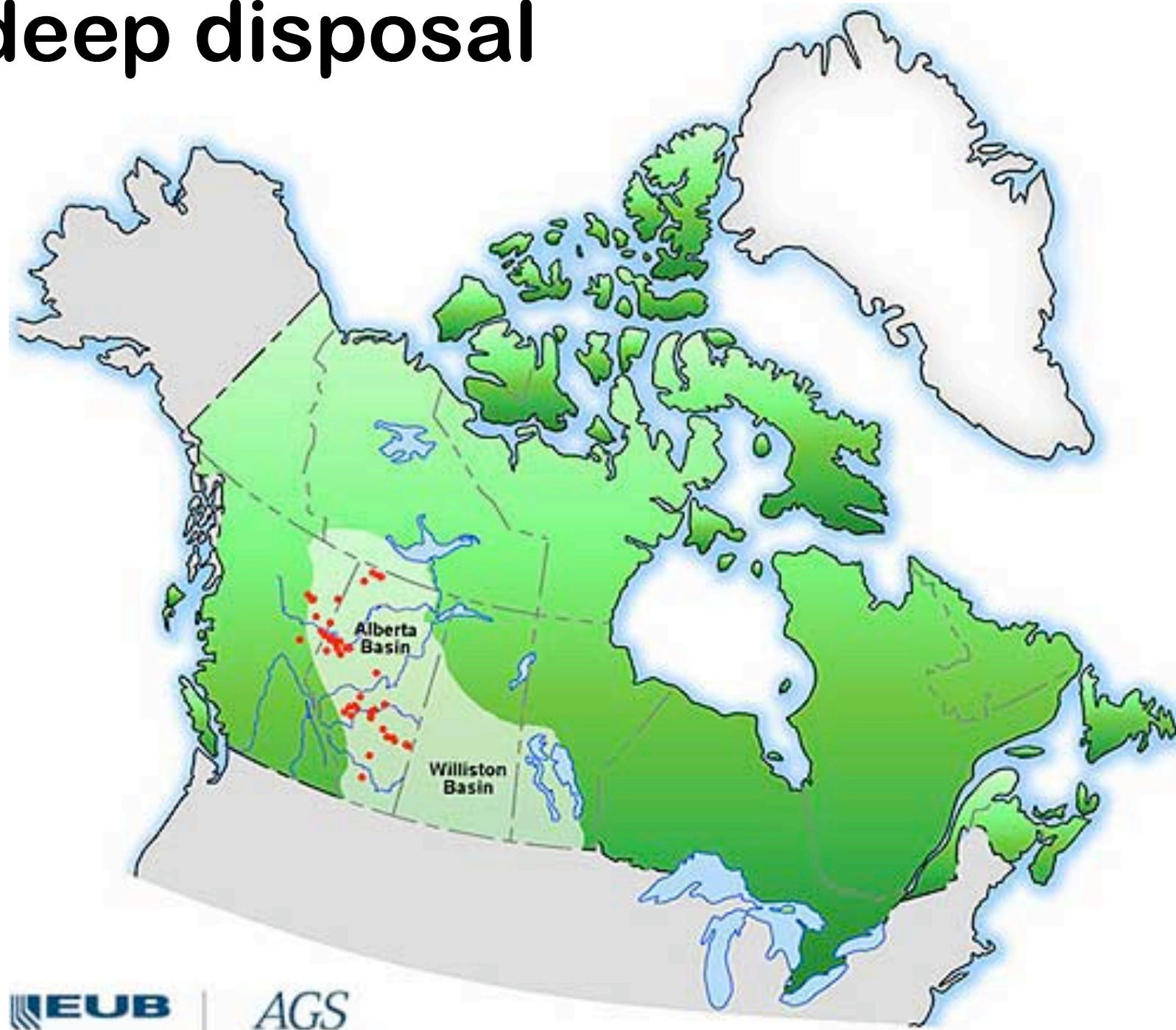
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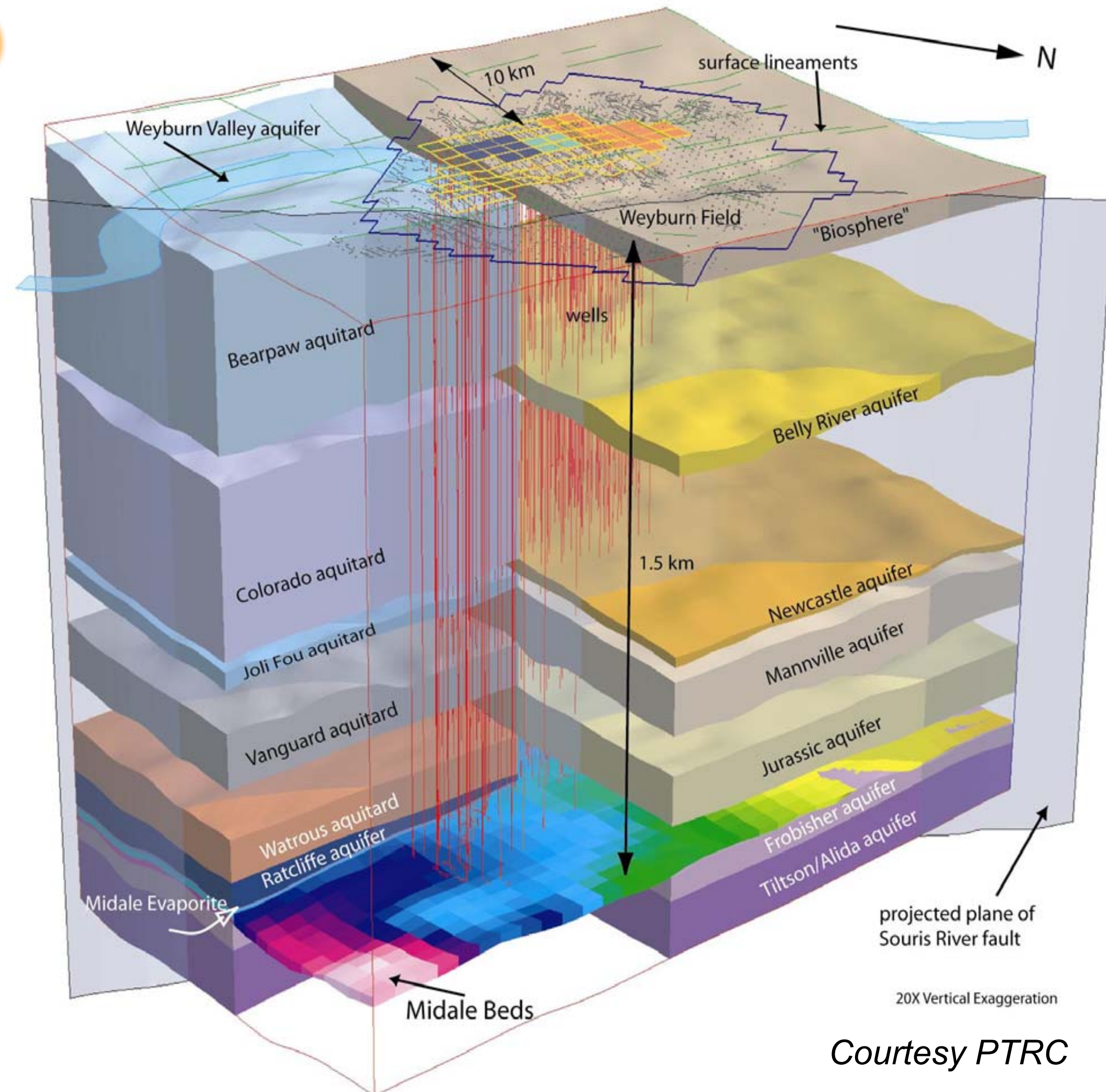


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CO₂ storage question:

- can CO₂ be stored?

- CO₂ Storage has proven to be economically feasible ie.:
 - Weyburn EOR in Canada for EOR (CO₂ from Great Plains Gasifier)
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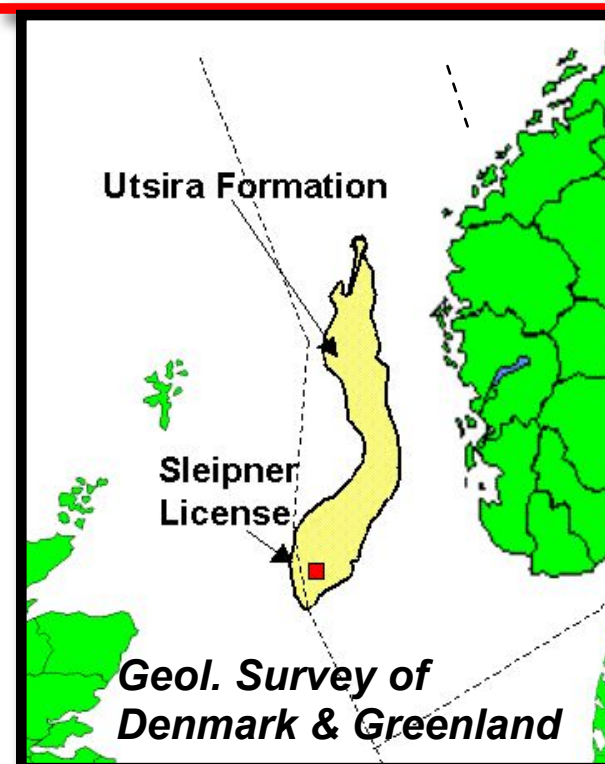
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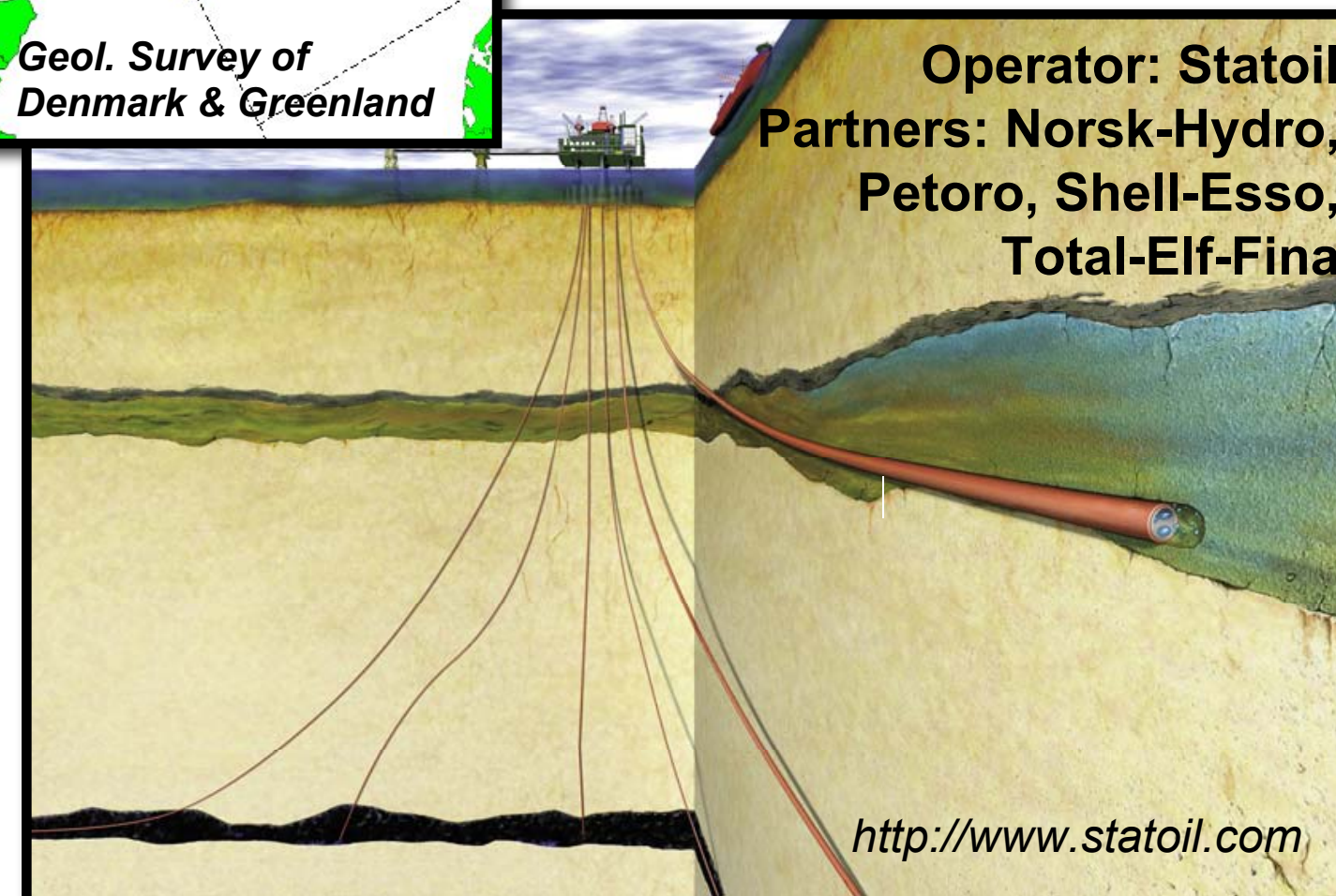
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Sleipner Vest project demonstrates 1st order viability of commercial storage



FIRST major attempt at large volume CO₂ sequestration, offshore Norway. Active since 1996. Monoethanolamine (MEA) capture

**Economic driver: Norwegian carbon tax on industry (\$50/ton C)
Cost of storage: \$15/ton C**



**Operator: Statoil
Partners: Norsk-Hydro, Petoro, Shell-Esso, Total-Elf-Fina**

**Target: 1 MM t CO₂/yr.
So far, 10 MM t**

Miocene Aquifer: DW fan complex
➤ 30-40% porosity, 200 m thick
➤ high perm. (~3000 mD)
➤ between 15-36 °C – w/i critical range

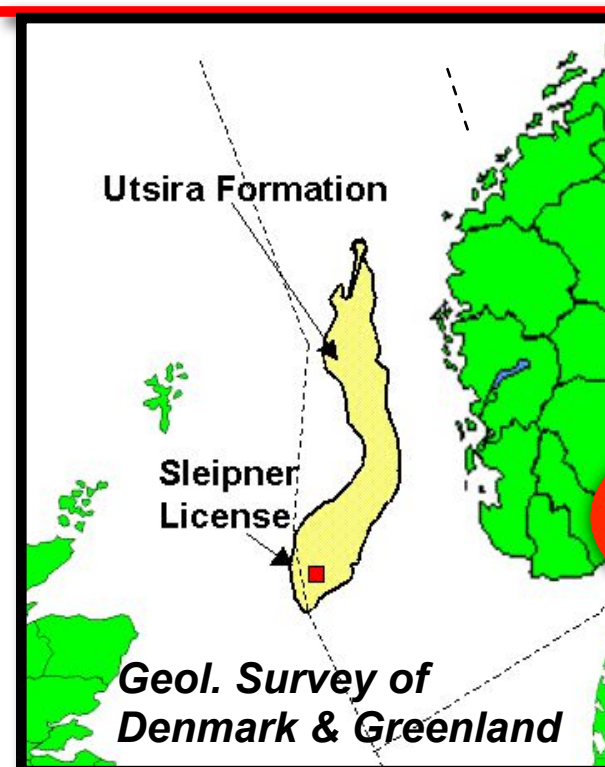
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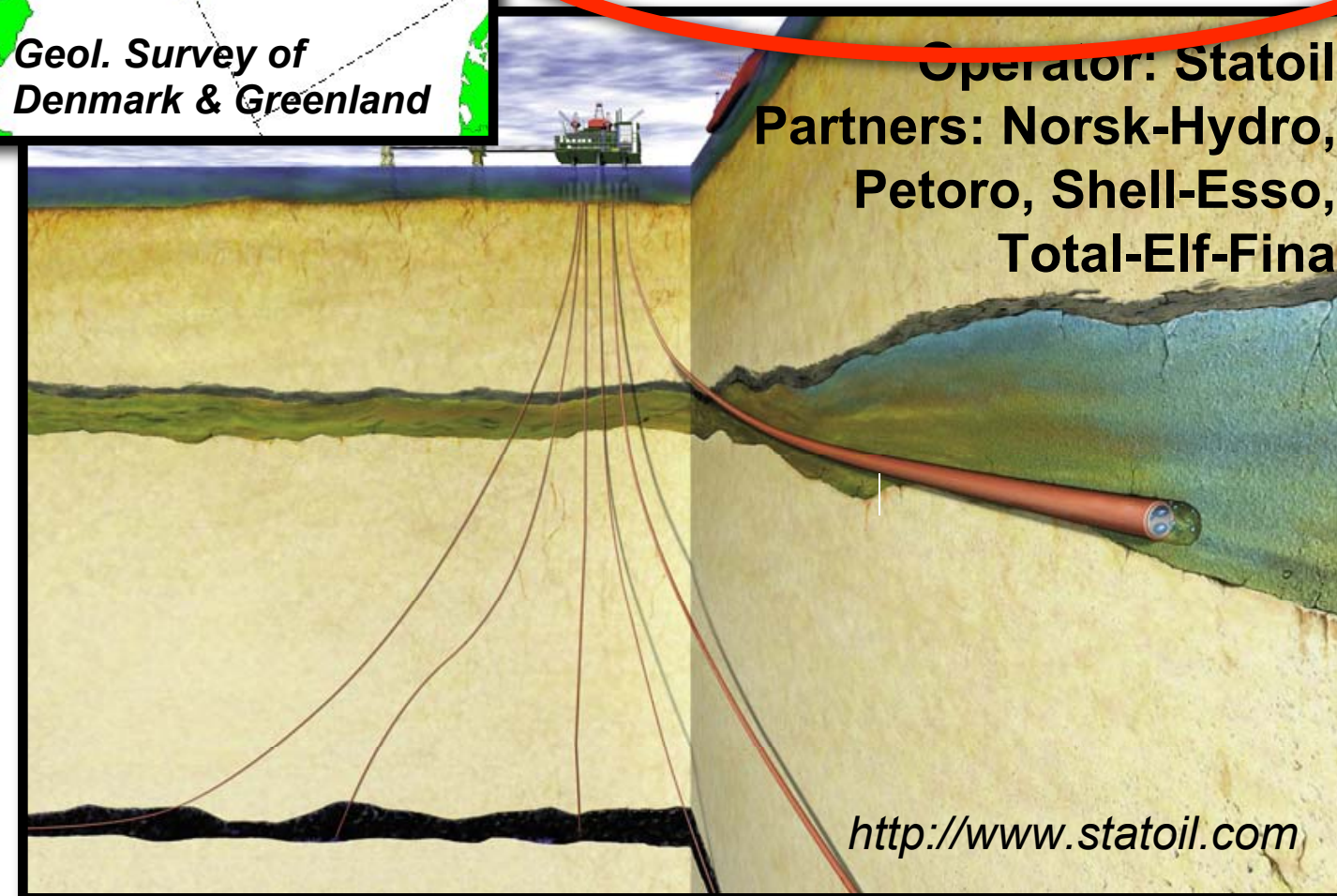
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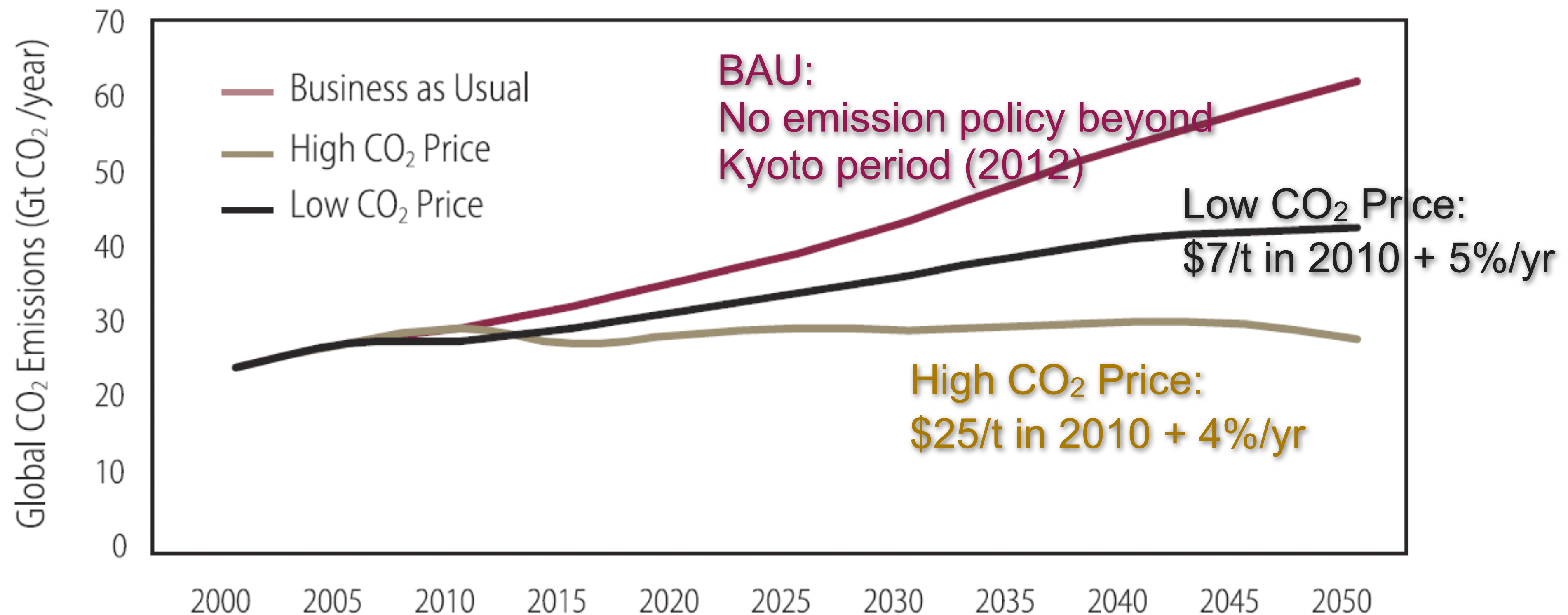
yes, there are
several large
demonstration
projects



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CO₂ Emissions stabilized with high CO₂ prices

(Deutch & Moniz, 2007)



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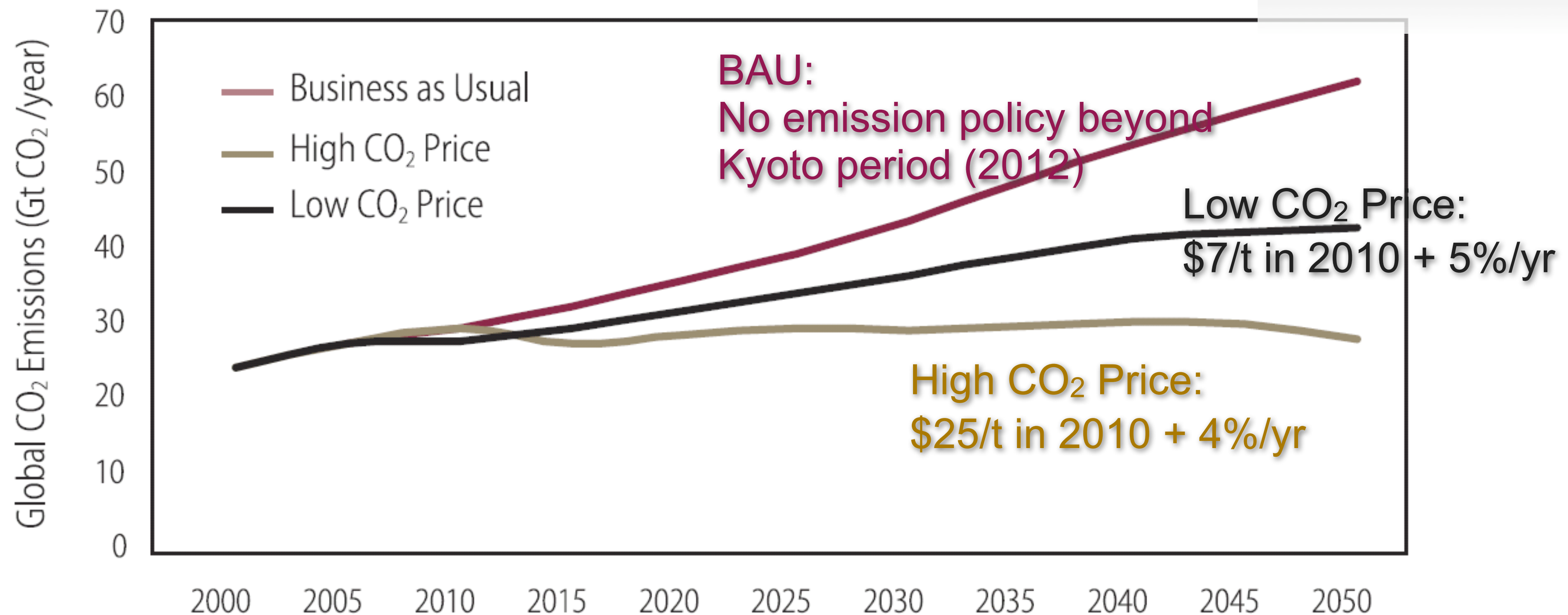
155 SOUTH 1452 EAST ROOM 380 SALT LAKE CITY, UTAH 84112 801-585-1233

CO₂ Emissions stabilized with high CO₂ prices

GCC question:

(Deutch & Moniz, 2007)

- can the developed countries of the world affect global CO₂ emissions?



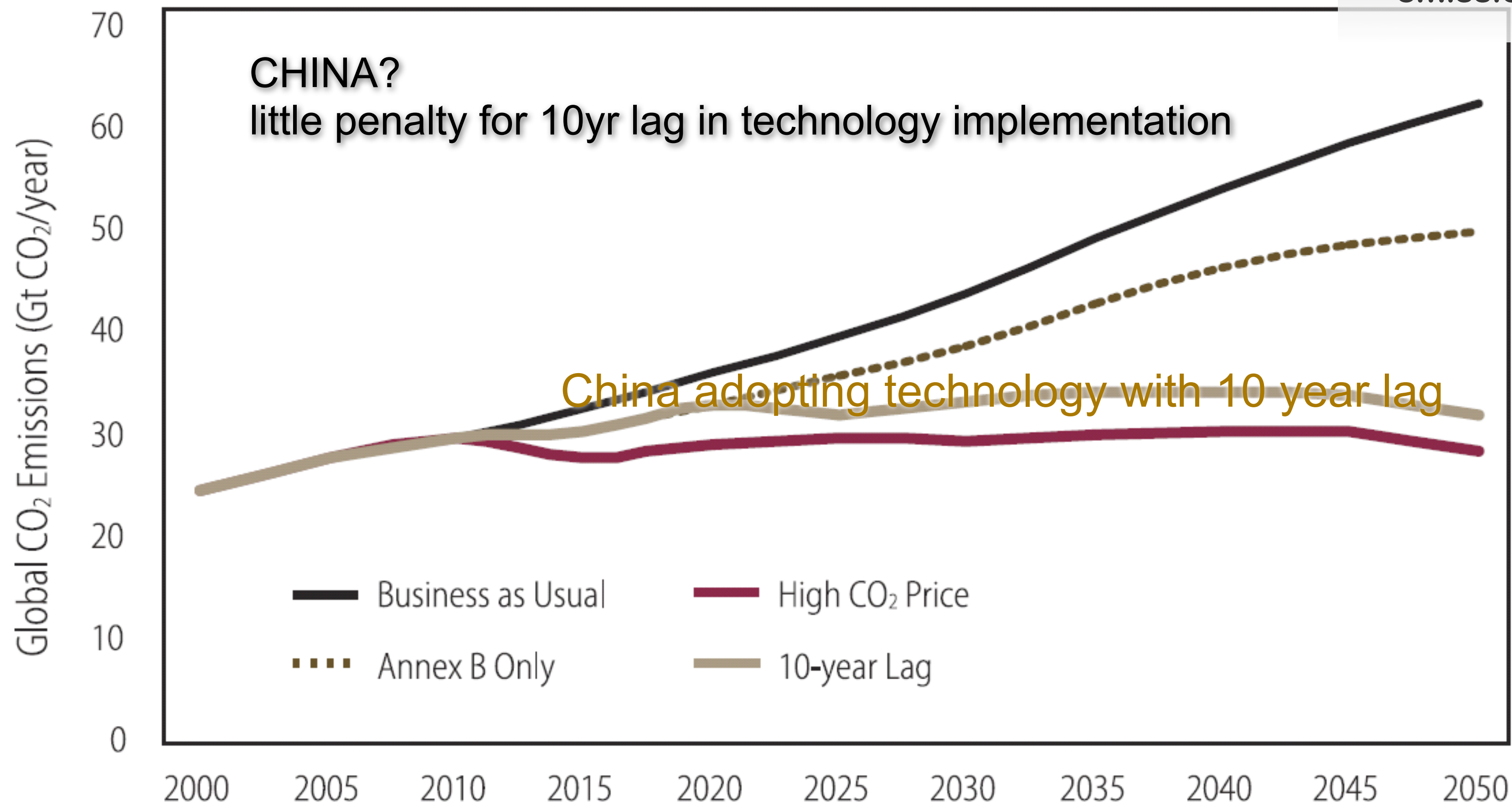
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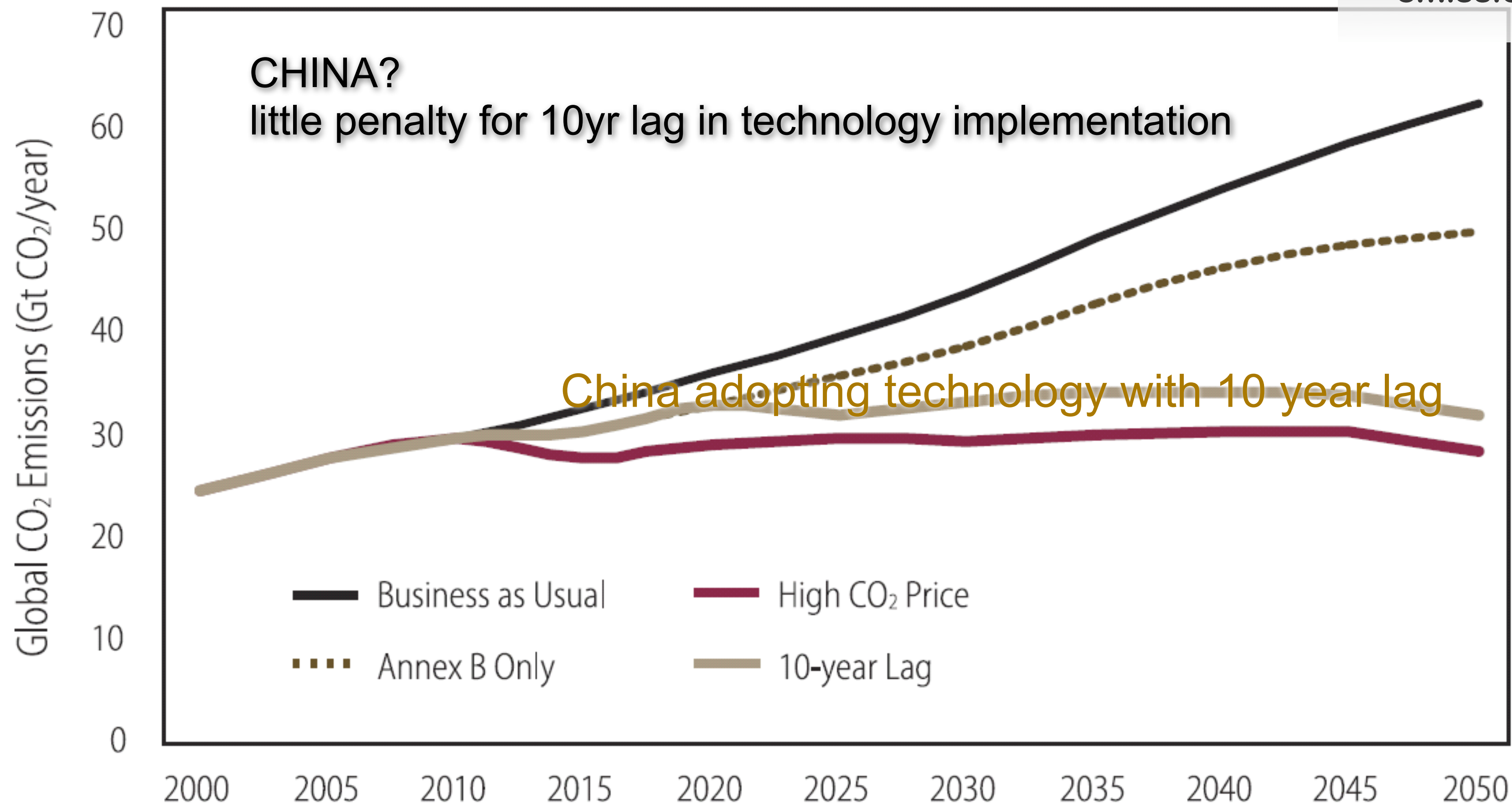
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yes, by finding low cost solutions that the developing countries can adopt



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ICSE method question:

- what is the research approach of ICSE?

Predictive Science

Multidiscipline Simulation Science:
hierarchically couple experimental & simulation data
verification, validation & UQ → discovery & innovation

ICSE method question:

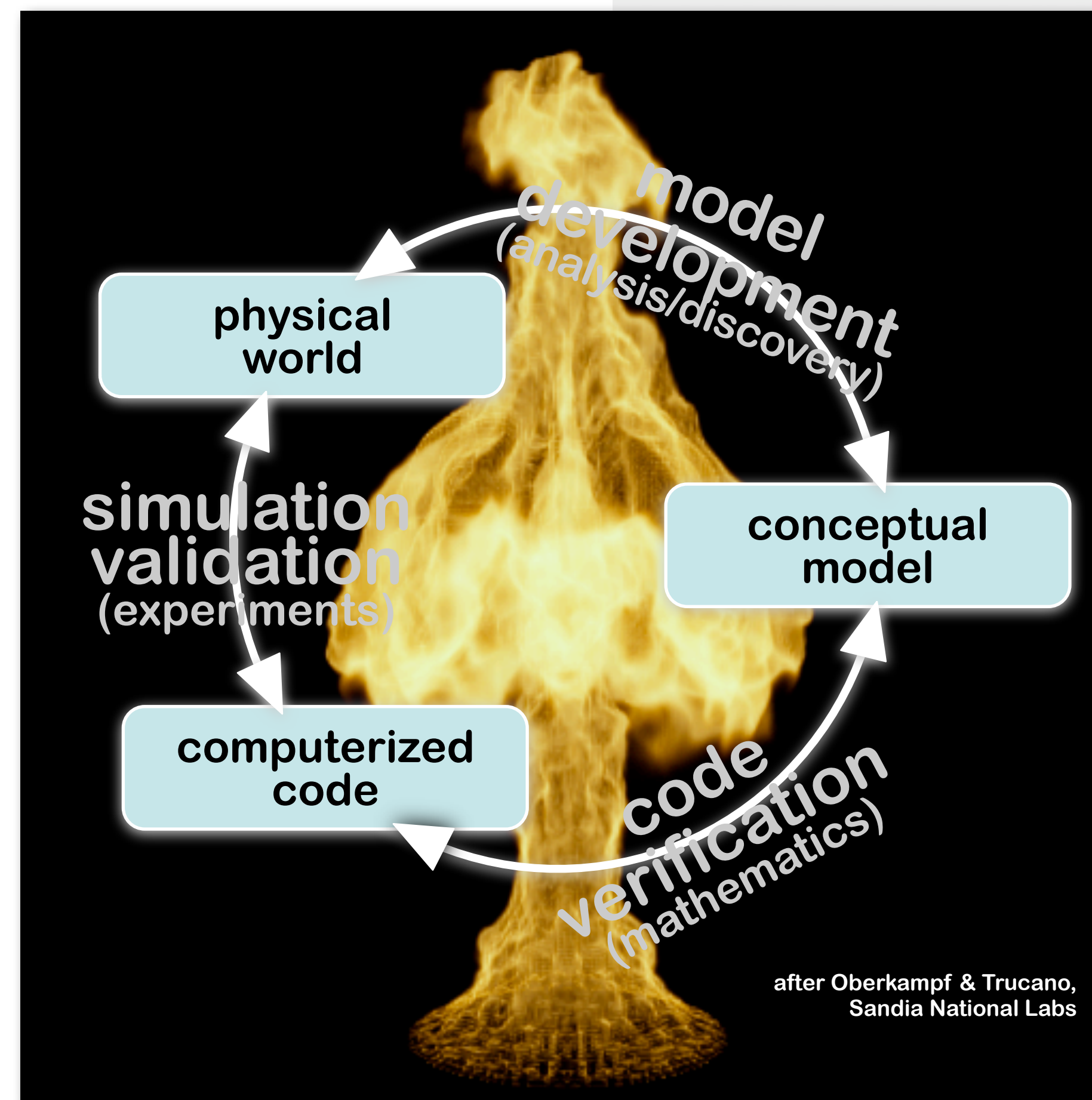
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★ AIAA, "Guide for the Verification and Validation of Computational Fluid Dynamics Simulations," (1998)



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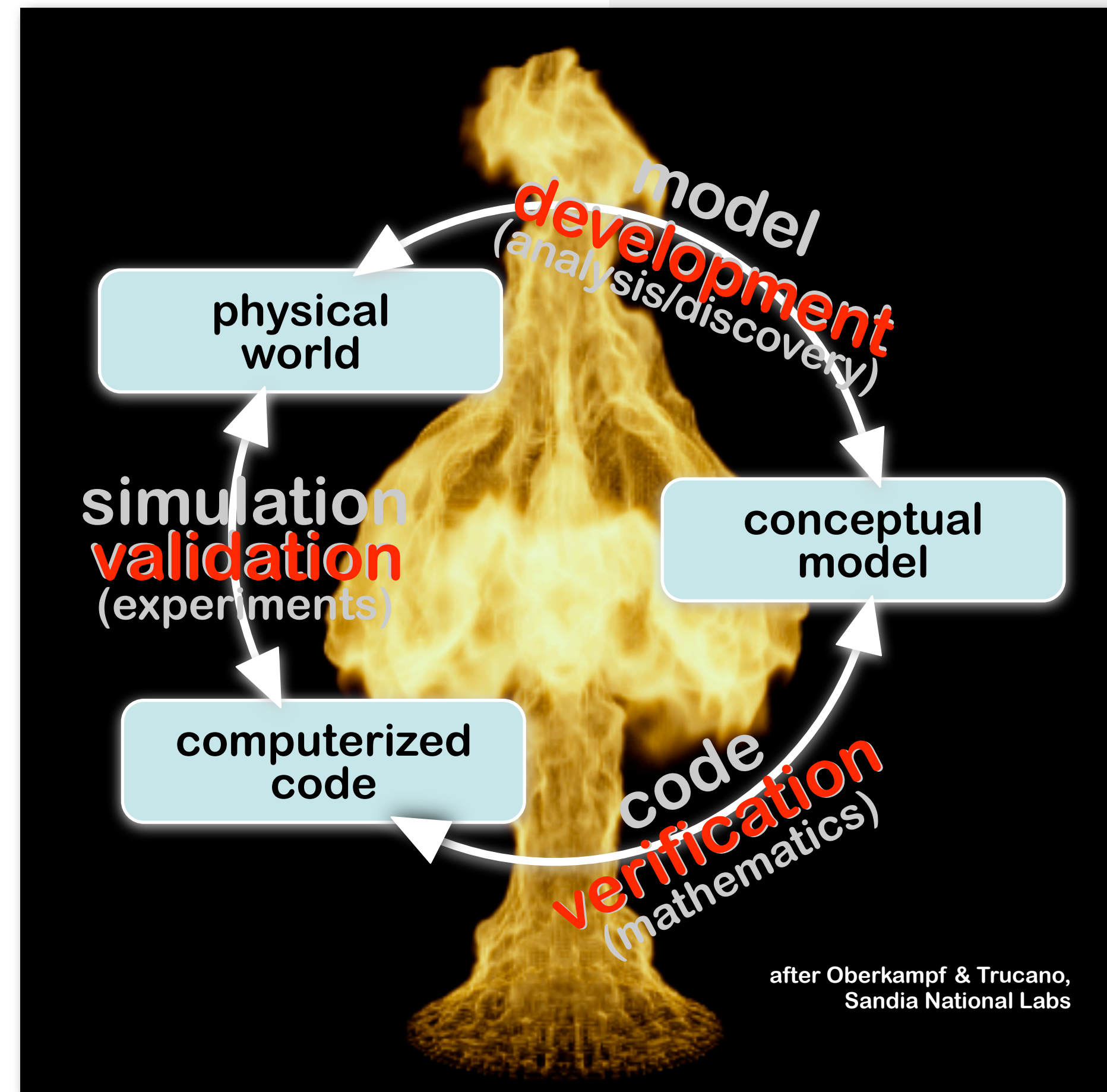
● 155 SOUTH 1452 EAST ROOM 380 ● SALT LAKE CITY, UTAH 84112 ● 801-585-1233

Predictive Science

ICSE method question:

Multidiscipline Simulation Science:
hierarchically couple experimental & simulation data
verification, validation & UQ → discovery & innovation

- **Loop Cycle Time:**
too fast: risk of trying to extract physical insight from numerical noise
too slow: risk of spending inordinate amount of resources on dumb ideas.
- **V&V provide guidance on optimizing cycle transfer rate to improve predictive quality**



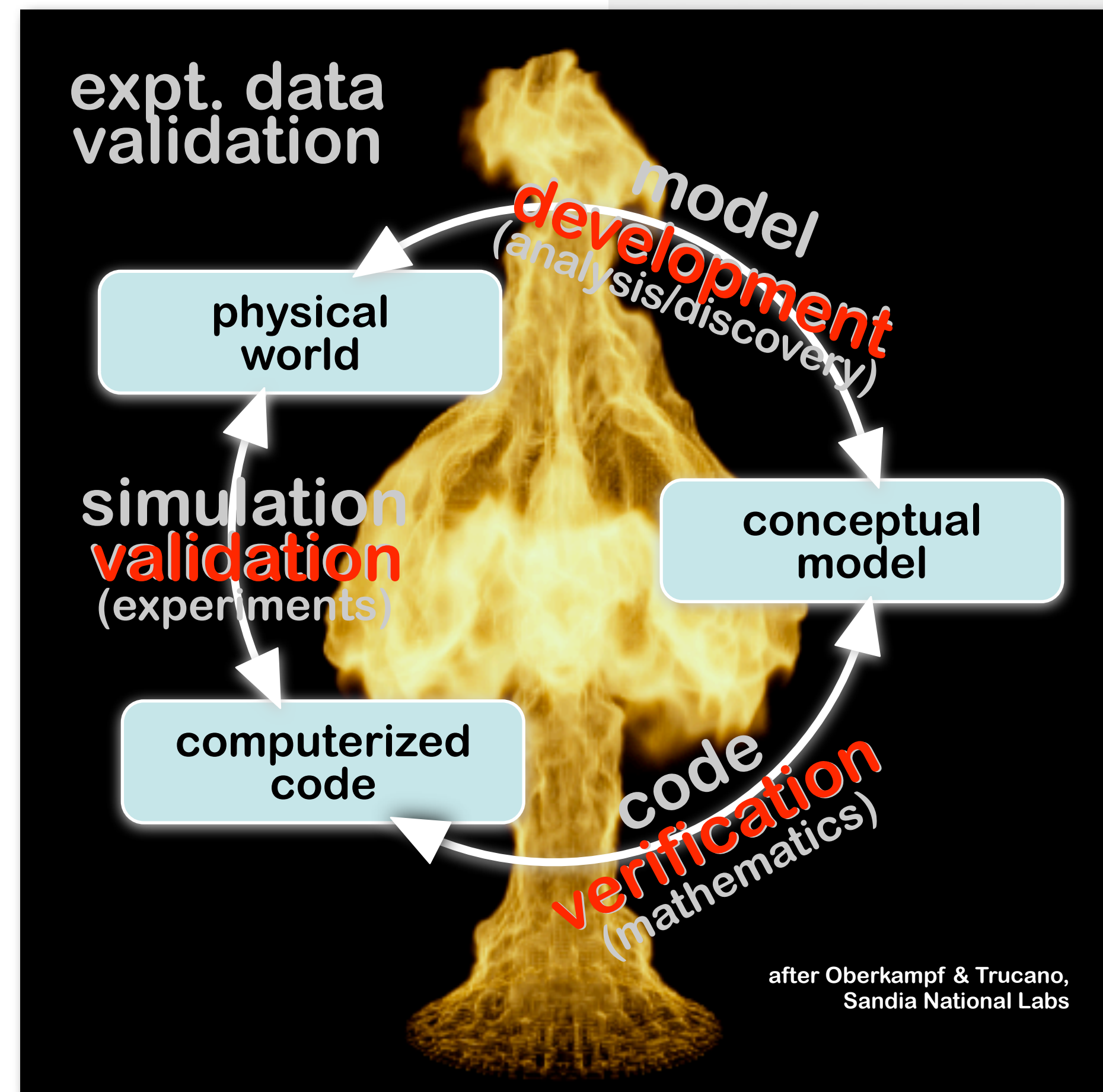
★ AIAA, "Guide for the Verification and Validation of Computational Fluid Dynamics Simulations," (1998)

Predictive Science

ICSE method question:

Multidiscipline Simulation Science:
hierarchically couple experimental & simulation data
verification, validation & UQ → **discovery & innovation**

- **Loop Cycle Time:**
too fast: risk of trying to extract physical insight from numerical noise
too slow: risk of spending inordinate amount of resources on dumb ideas.
- **V&V provide guidance on optimizing cycle transfer rate to improve predictive quality**



★ AIAA, "Guide for the Verification and Validation of Computational Fluid Dynamics Simulations," (1998)

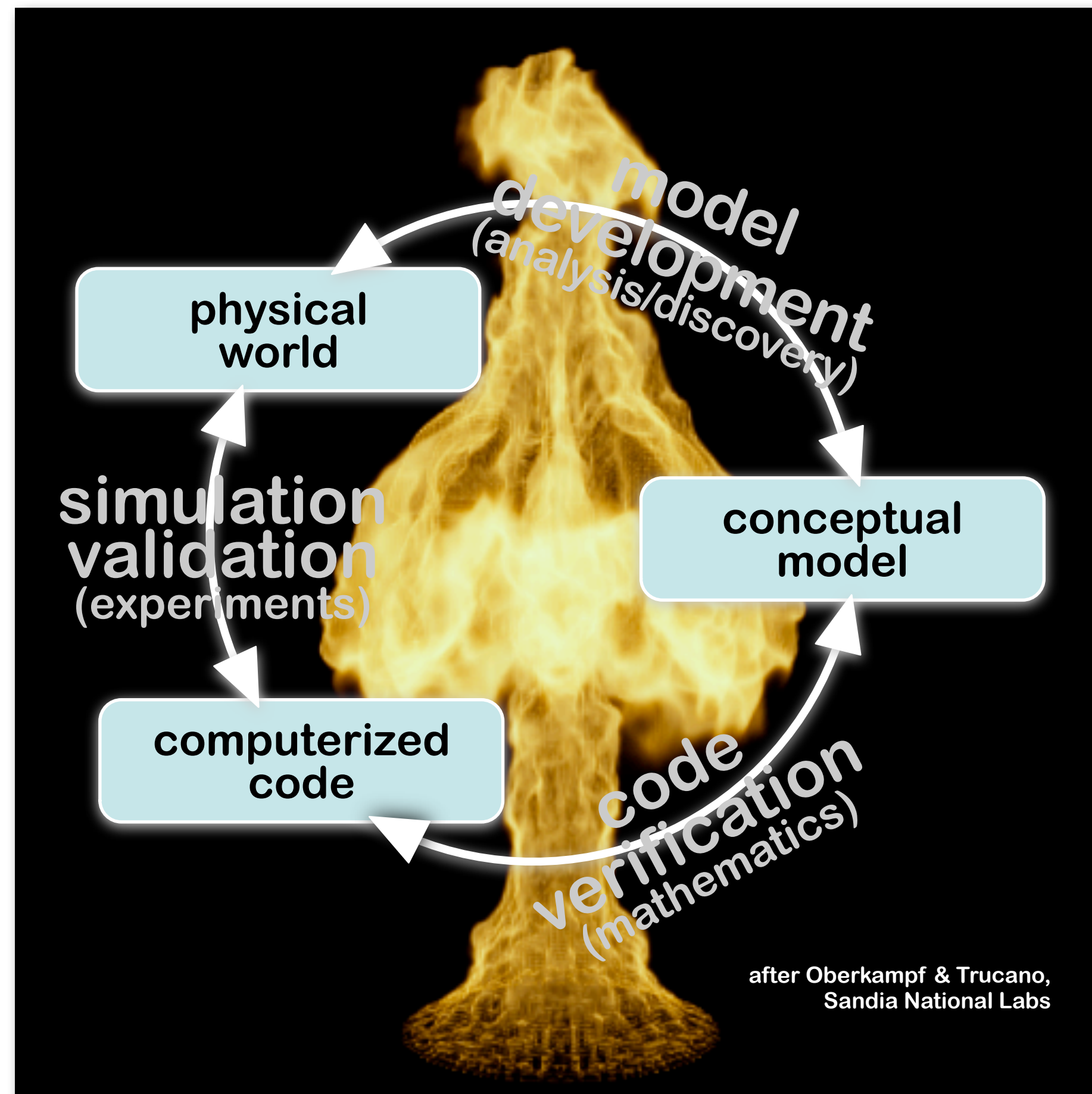
Predictive Science

Multidiscipline Simulation Science:
hierarchically couple experimental & simulation data
verification, validation & UQ → **discovery & innovation**

ICSE method question:

- what is the research approach of ICSE?

obtain
quantified
predictivity
through
formal
verification &
validation
methods



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Utah Heavy Oil Program



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● 155 SOUTH 1452 EAST ROOM 380 ● SALT LAKE CITY, UTAH 84112 ● 801-585-1233

Utah Heavy Oil Program



- **Mission:** to provide interdisciplinary research support to federal and state constituents for addressing the wide-ranging issues surrounding the potential of an industry for oil shale, oil sands and heavy oil production in the United States.
 - characterization of the resource
 - production and processing of the resource
 - environmental and legal issues
 - business and market issues

Utah Heavy Oil Program



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- **Task 1: Information, Data and Simulation Repository** for all unconventional oil, including heavy oil, tar sands (oil sands), and oil shale

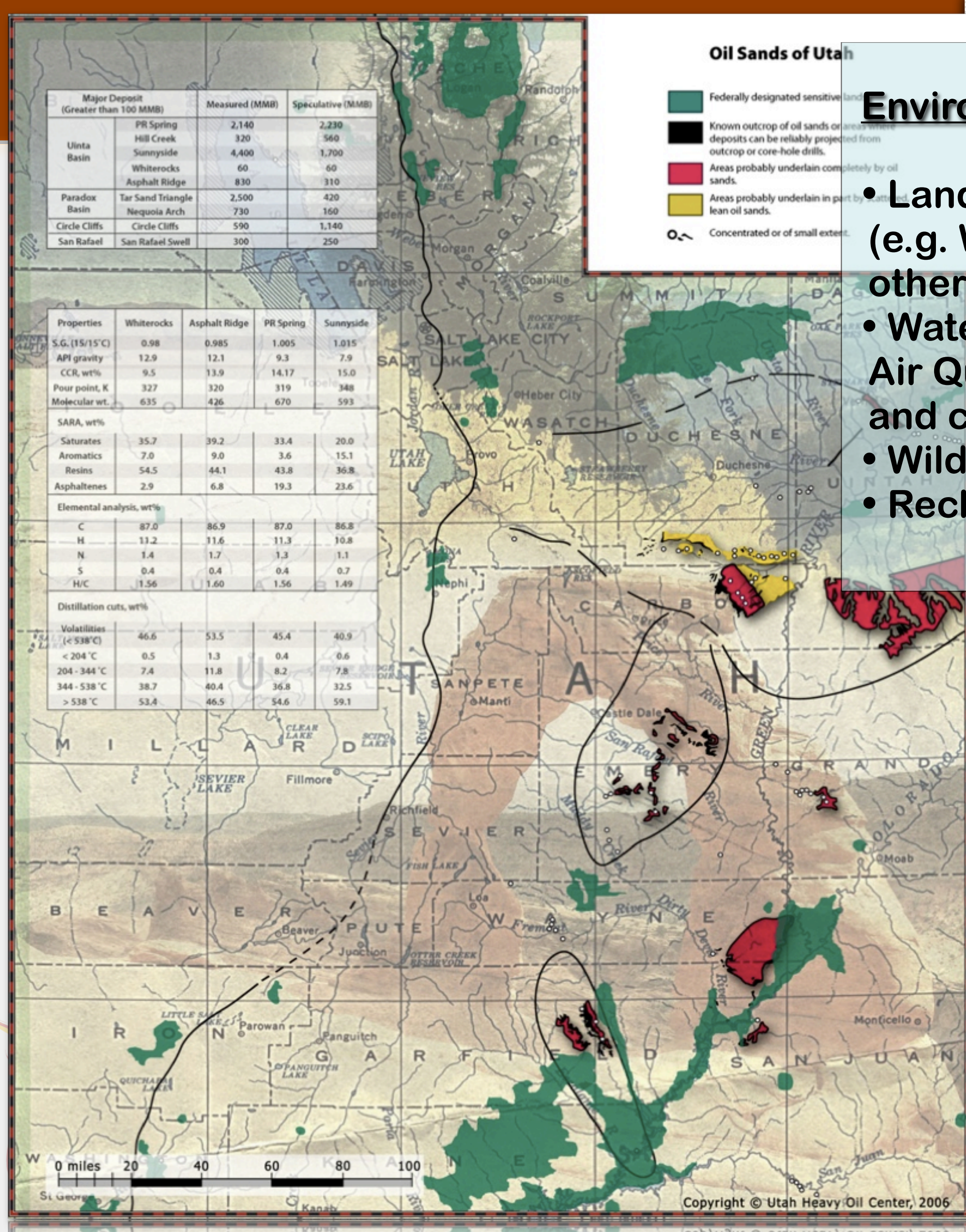
Utah Heavy Oil Program



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 - business and market issues
- **Task 1: Information, Data and Simulation Repository** for all unconventional oil, including heavy oil, tar sands (oil sands), and oil shale
- **Task 2: Solicited Sponsored Research:** short-term projects to clarify issues and seek solutions to challenges for managing and utilizing these natural resources.



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Environmental Issues

- Land Use and Resource Conflicts (e.g. WSAs, T&E species, arch. sites, other minerals or leases)
- Water Availability, Use and Quality
- Air Quality (including cum. impacts and carbon emissions)
- Wildlife Conflicts
- Reclamation Requirements

Legal Issues

- Planning & Leasing – FLPMA, NEPA, ESA, Arch Res. Prot. Act, Mult Mineral Dev. Act, Combined Hydro Carbon Leasing Act, Energy Policy Act of 2005
- Water – State Water Law; Clean Water Act; Colorado River Compact
- Air Quality – Clean Air Act
- Reclamation – Surface Mining Control and Reclamation Act

Utah Heavy Oil Program

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clarify issues and seek solutions to utilizing these natural resources.



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Utah Heavy Oil Program

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San Rafael Swell Wilderness Study

Task 2: Conducted sponsored research to clarify issues and seek solutions to utilizing these natural resources.



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Utah Heavy Oil Program

Environmental Issues

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Dirt Devil Wilderness Study Area
(tar sands triangle)

clarify issues and seek solutions to
utilizing these natural resources.



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Utah Heavy Oil Program

Environmental Issues

- **Mission:** to provide interdisciplinary research support to federal agencies in addressing the wide-ranging issues in industry for oil shale, oil sands and tar sands in the United States.
- Land Use and Resource Conflicts (e.g. WSAs, T&E species, arch. sites, other minerals or leases)
- Water Availability, Use and Quality
- Air Quality (including cum. impacts and carbon emissions)
- Wildlife Conflicts
- Reclamation Requirements

Legal Issues

- Task 1: **Information, Data and Simulation** of unconventional oil, including heavy oil, oil shale, oil sands, tar sands, and bitumen
- Task 2: **Solicited Sponsored Research** to clarify issues and seek solutions to challenges for managing and utilizing these natural resources.
- Planning & Leasing – FLPMA, NEPA, ESA, Arch Res. Prot. Act, Mult Mineral Dev. Act, Combined Hydro Carbon Leasing Act, Energy Policy Act of 2005
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Utah Heavy Oil Program

Environmental Issues

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The Book Cliffs photo by Harry Barber

- Task 2: **Solicited Sponsored Research** clarify issues and seek solutions to utilizing these natural resources.

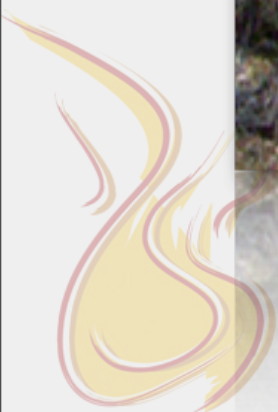


Research support to federal
wide ranging issues
for oil shale, oil sands
sites

Research in Technology:

- in situ oil shale/sand simulations
- water use
- upgrading
- characterization
- legal issues

Repository for all
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ort-term projects to
nges for managing and



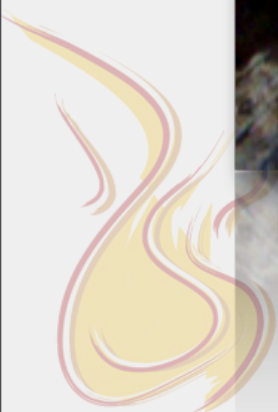


Research support to federal
with a wide range of issues
for oil shale, oil sands
and related technologies.

Research in Technology:

- in situ oil shale/sand simulations
- water use
- upgrading
- characterization
- legal issues

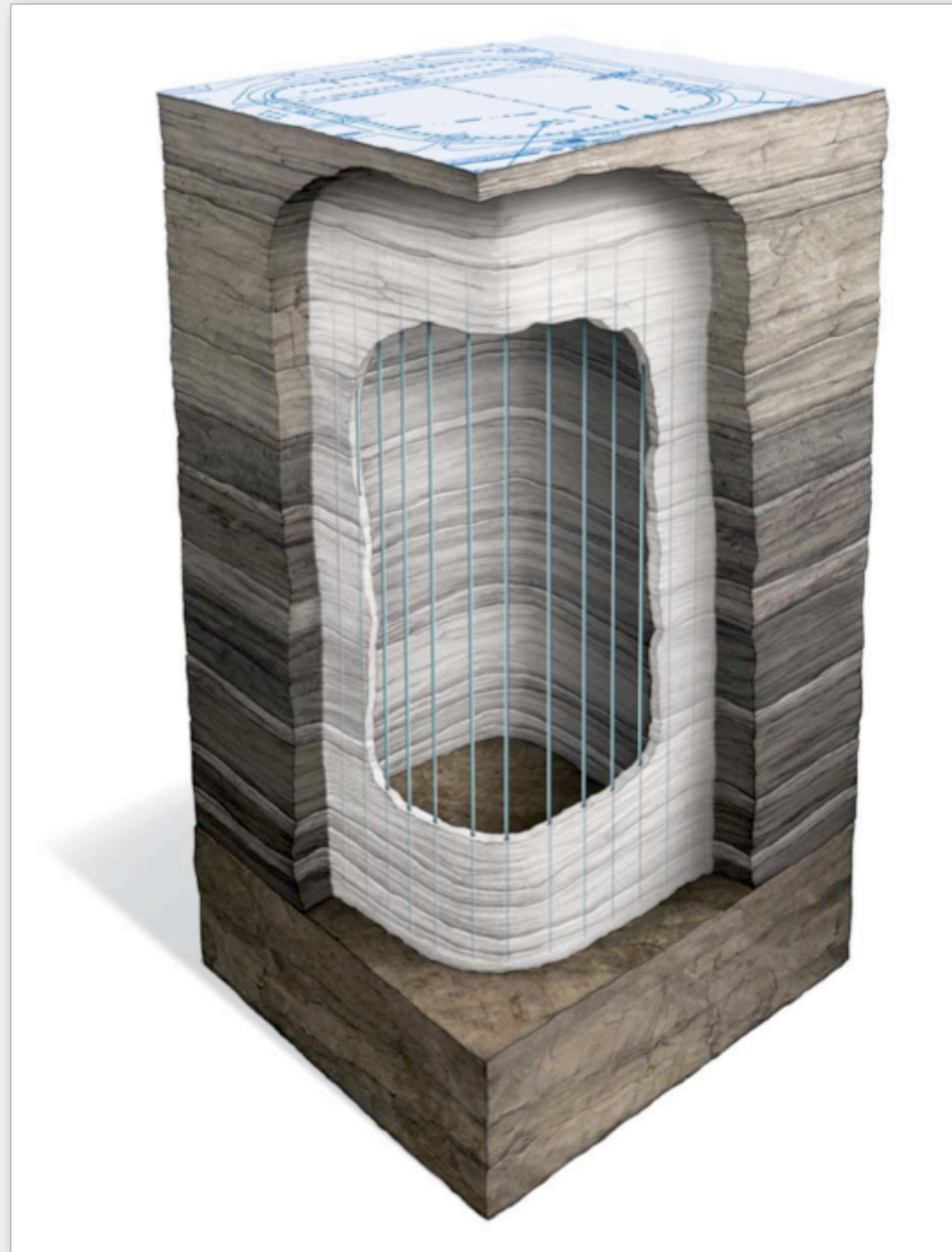
Repository for all
oil sands (oil sands), and
short-term projects to
develop changes for managing and



Utah Heavy Oil Program



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olinary research support to federal
pressing the wide ranging issues
n industry for oil shale, oil sands
e United States

Research in Technology:

resource

- in situ oil shale/sand simulations
- water use
- upgrading
- characterization
- legal issues

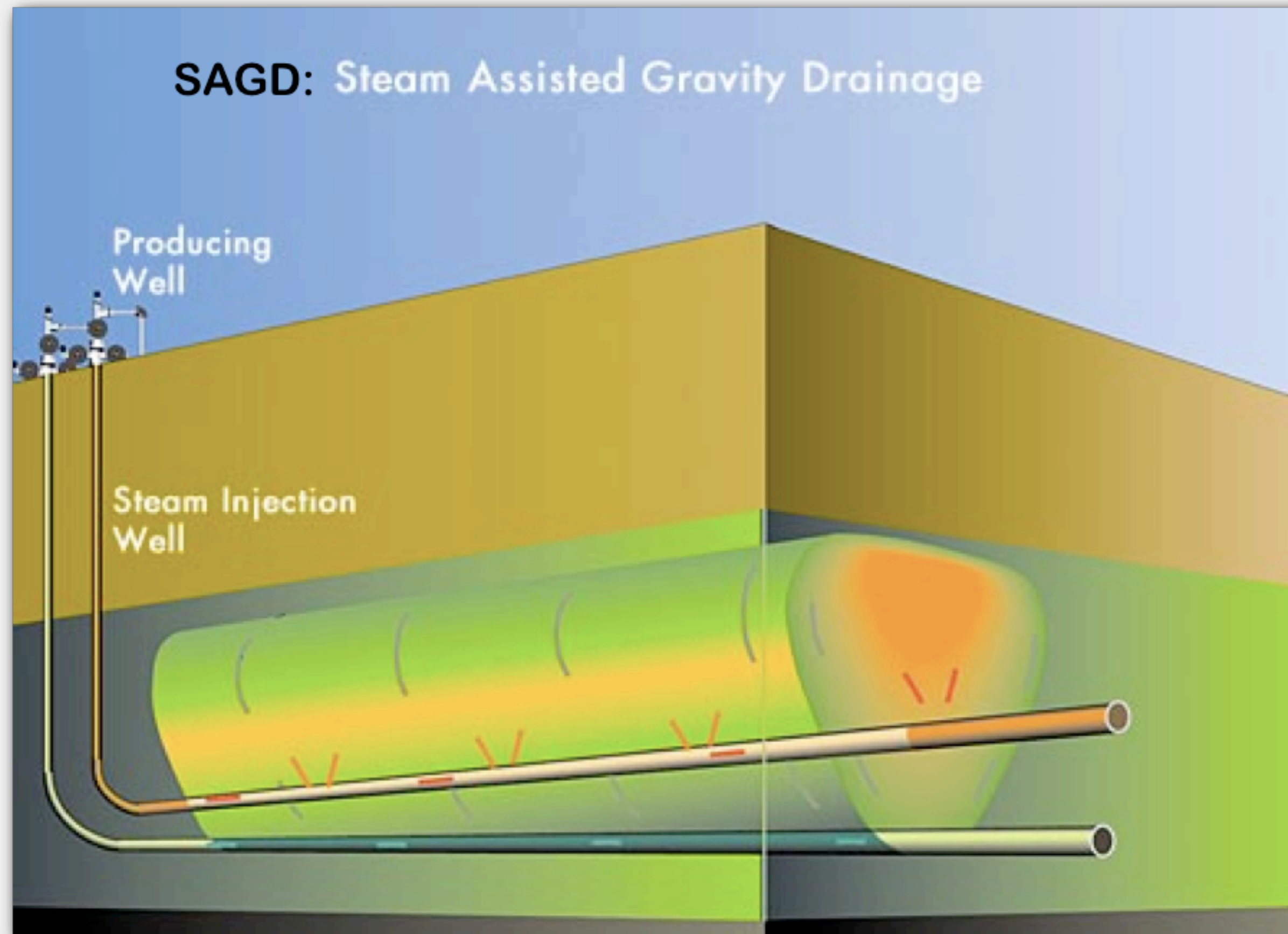
Simulation Repository for all
heavy oil, tar sands (oil sands), and

research: short-term projects to
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es.



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Utah Heavy Oil Program



utilizing these natural resources.

research support to federal

Research in Technology:

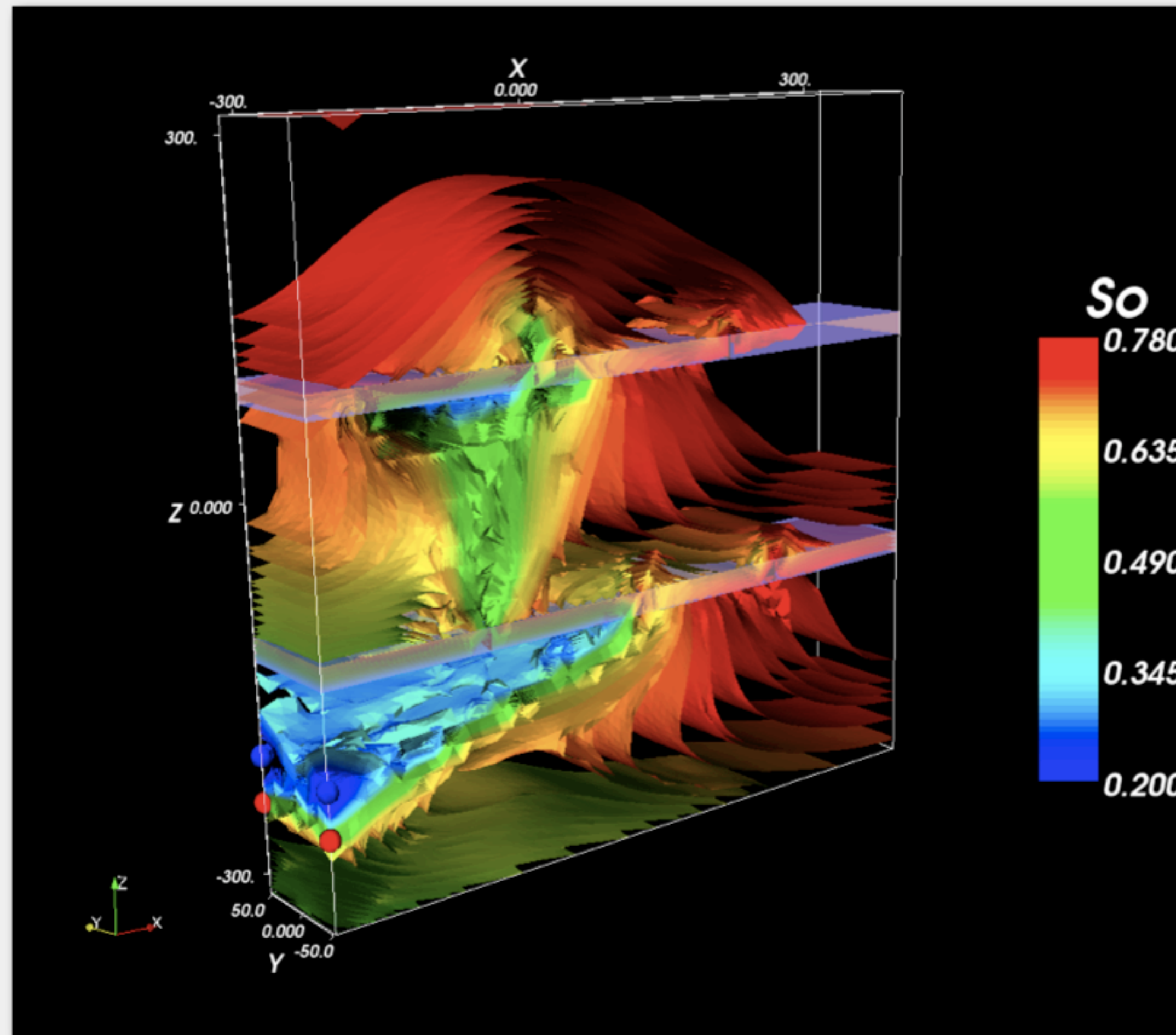
- in situ oil shale/sand simulations
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Utah Heavy Oil Program



research support to federal
the wide ranging issues
ry for oil shale, oil sands
States

Research in Technology:

- in situ oil shale/sand simulations
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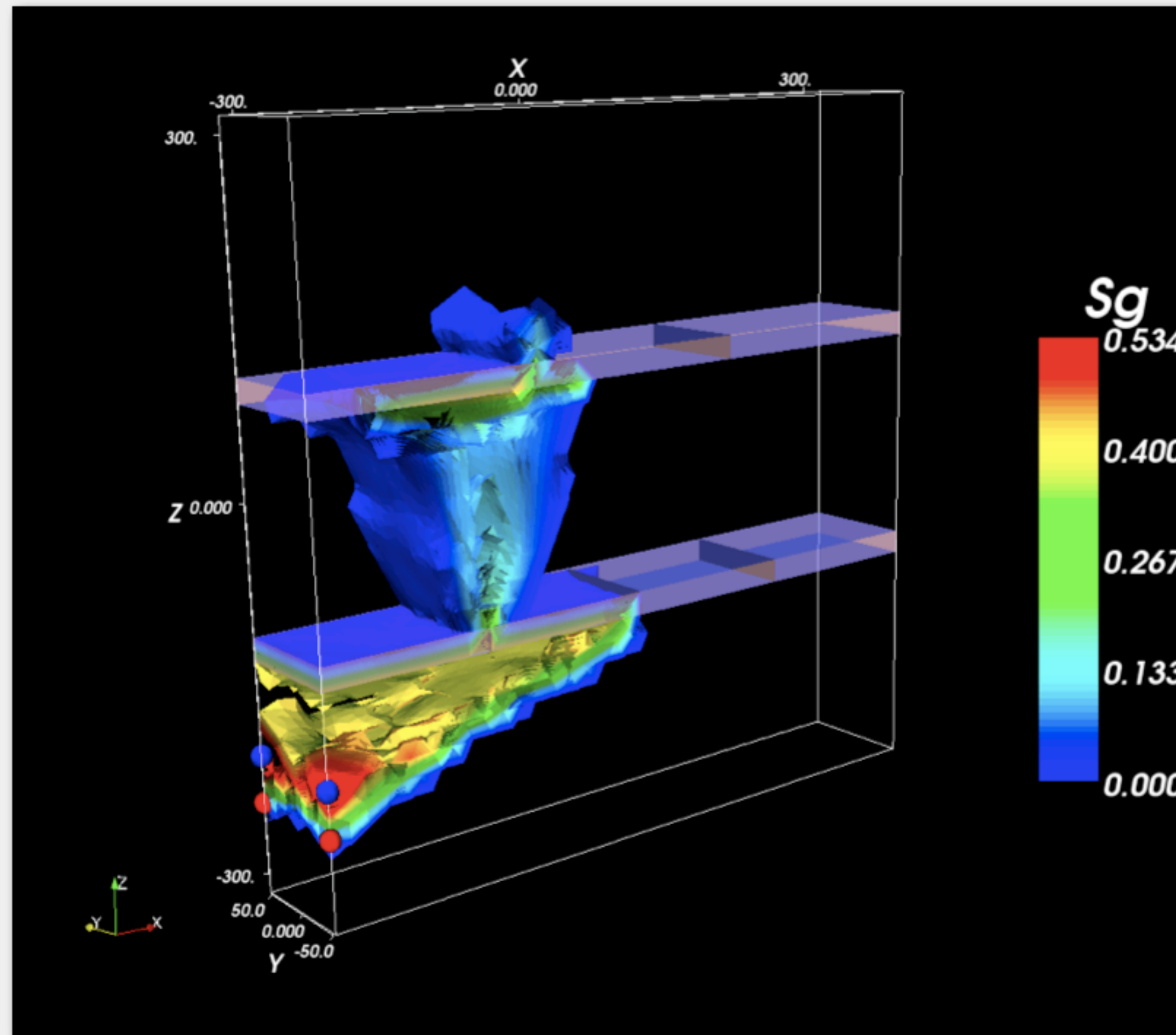
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Utah Heavy Oil Program



research support to federal
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Research in Technology:

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Utah Heavy Oil Program

- ArcIMS® Map Server Interface

- Data & Information Repository (& portal to other repositories)

- simulation software repository

Mission: to provide inter and state constituents for surrounding the potential and heavy oil production in

- characterization of the resource
- production and processing of
- environmental and legal issues
- business and market issues

Task 1: Information, Data & unconventional oil, including oil shale

- **Task 2:** Solicited Sponsored Research: to clarify issues and seek solutions to challenges utilizing these natural resources.

Public Portal & Repository

Utah Heavy Oil Program

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- business and market issues

Task 1: Information, Data & Information Repository: to provide information on unconventional oil, including oil shale

- **Task 2: Solicited Sponsored Research:** to clarify issues and seek solutions to challenges in utilizing these natural resources.



Public Portal & Repository

Utah Heavy Oil Program

- ArcIMS® Map Server Interface

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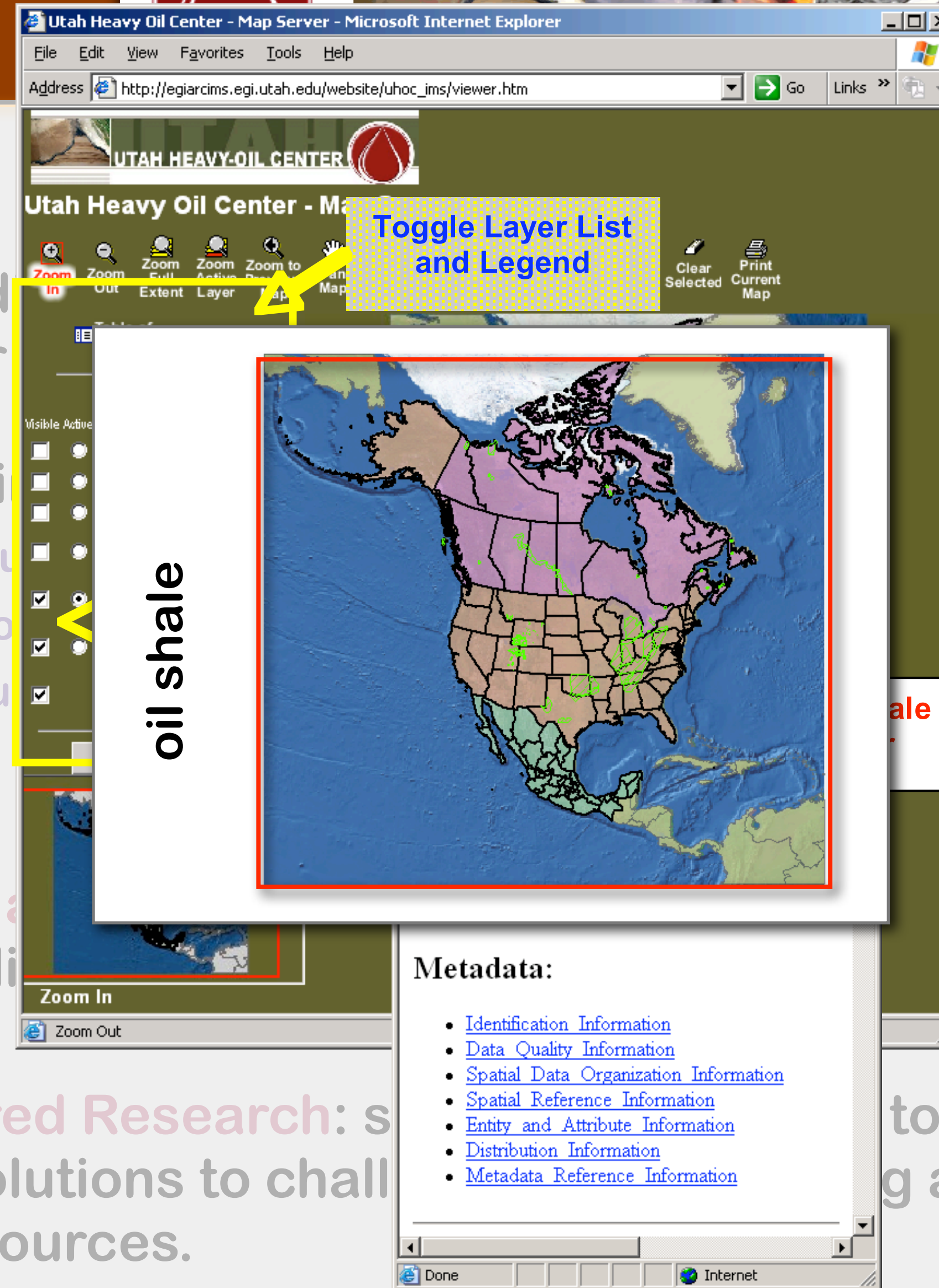
- simulation software repository

Mission: to provide inter and state constituents for surrounding the potential and heavy oil production in

- characterization of the resource
- production and processing of heavy oil
- environmental and legal issues
- business and market issues

Task 1: Information, Data & Simulation: to develop a comprehensive database of unconventional oil, including oil shale

- **Task 2: Solicited Sponsored Research:** to clarify issues and seek solutions to challenges in utilizing these natural resources.



Public Portal & Repository

Utah Heavy Oil Program

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Mission: to provide interdependent and state constituents for surrounding the potential and heavy oil production in the region

- characterization of the resource
- production and processing of heavy oil
- environmental and legal issues
- business development

Task 1: Information on unconventional oil shale

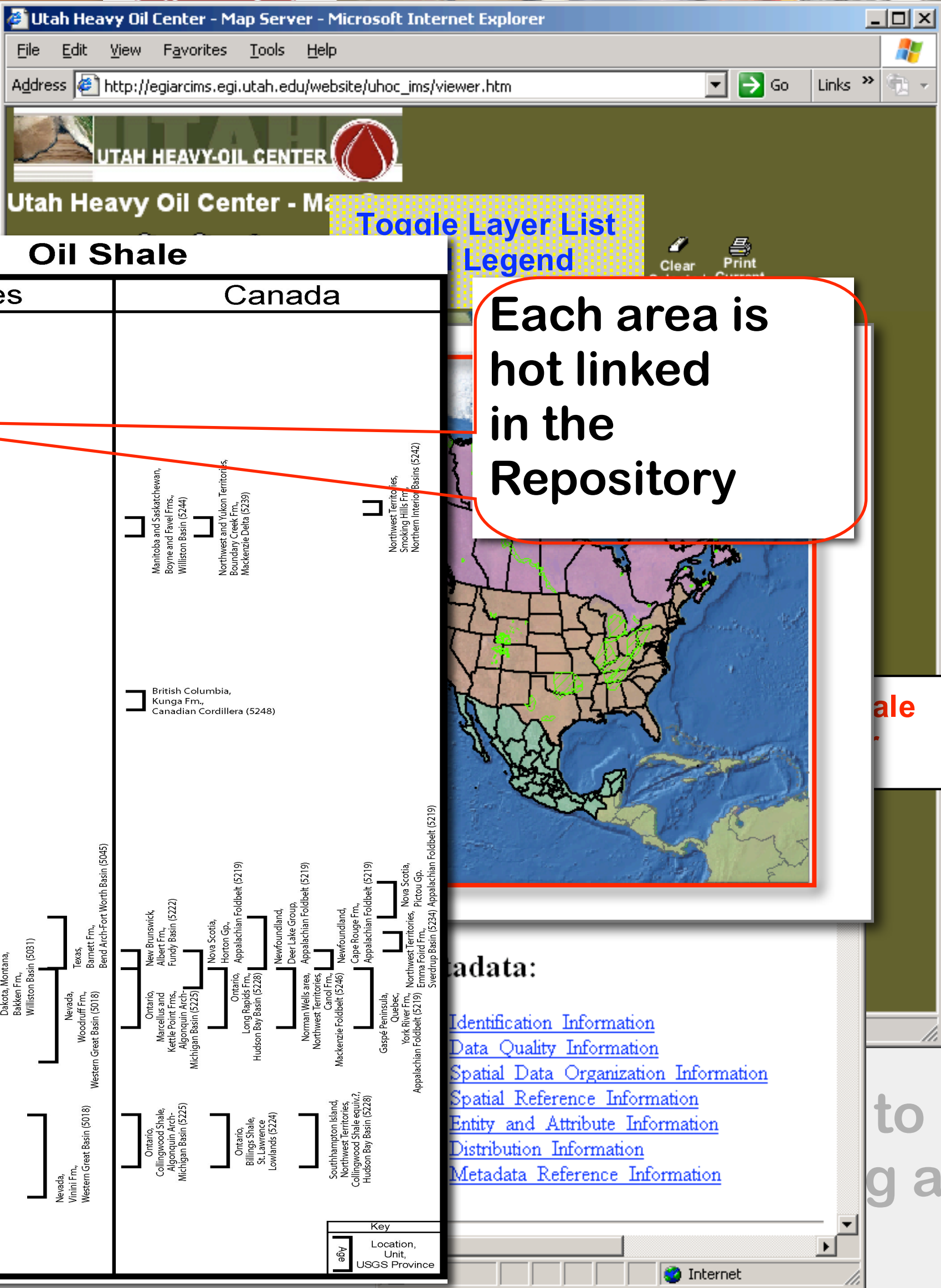
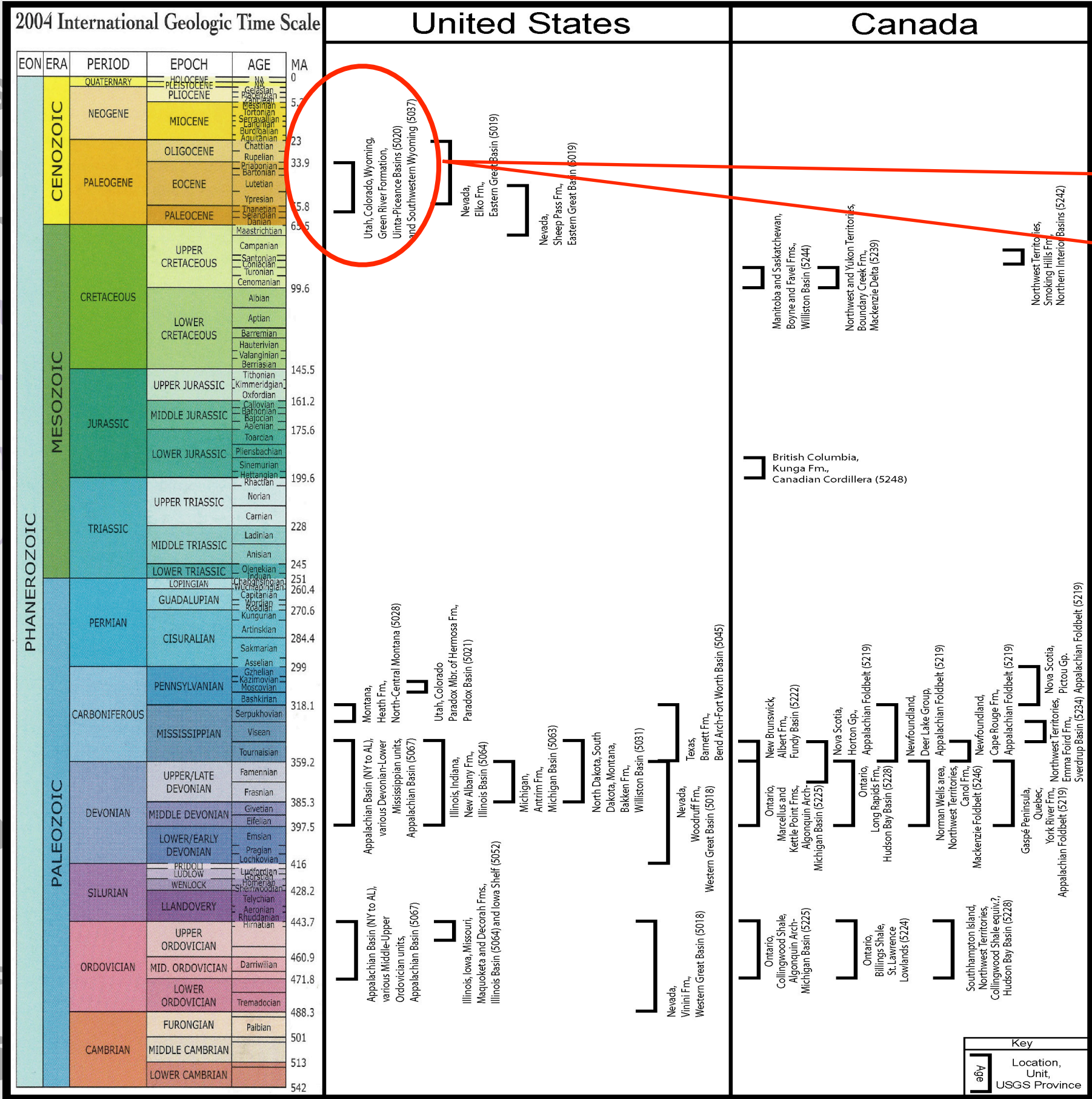
- **Task 2:** Software to clarify issues and seek solutions to challenge utilizing these natural resources.



Public Portal & Repository

Utah Heavy Oil Program

- ArcIMS® Map Server Interface
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- simulation software repository
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Public Portal & Repository

Utah Heavy Oil Program

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Task 1: Information, Data & simulation software repository for unconventional oil, including oil shale

- **Task 2:** Solicited Sponsored Research: to clarify issues and seek solutions to challenges utilizing these natural resources.

Utah Heavy Oil Center - Map Server - Microsoft Internet Explorer

Address: http://egiarcims.egi.utah.edu/website/uhoc_ims/viewer.htm

Utah Heavy Oil Center - Map Server

Toggle Layer List and Legend

Table of Contents

Active Layer Radio Button

Layer Visibility Checkbox

Metadata for Oil Shale Resources Layer

OilShaleResources

Metadata also available as

Metadata:

- [Identification Information](#)
- [Data Quality Information](#)
- [Spatial Data Organization Information](#)
- [Spatial Reference Information](#)
- [Entity and Attribute Information](#)
- [Distribution Information](#)
- [Metadata Reference Information](#)

Public Portal & Repository

CO₂ Capture technologies

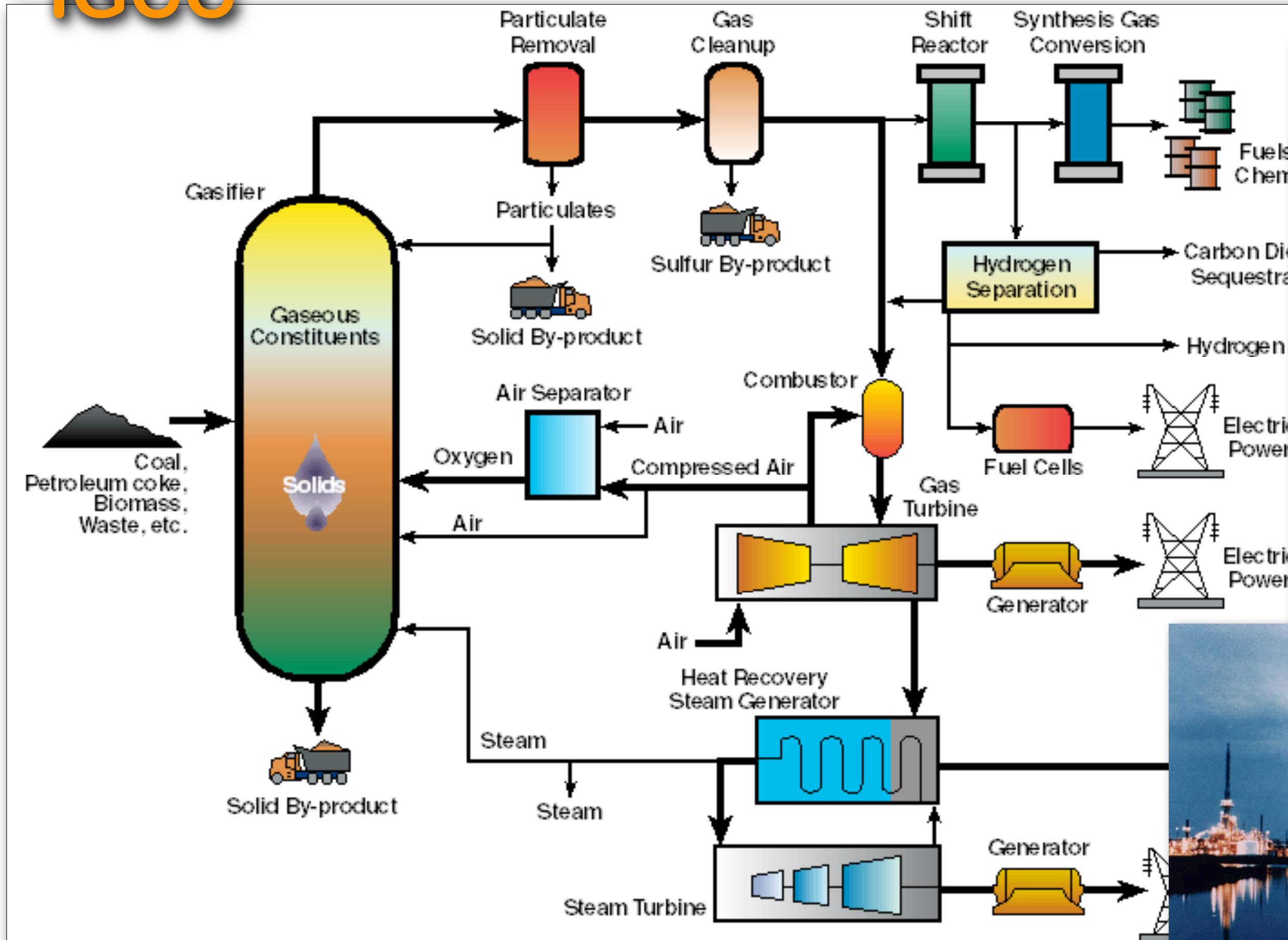
CO₂ Capture technologies

CO₂ capture question:

- what are the CO₂ capture technologies for coal?

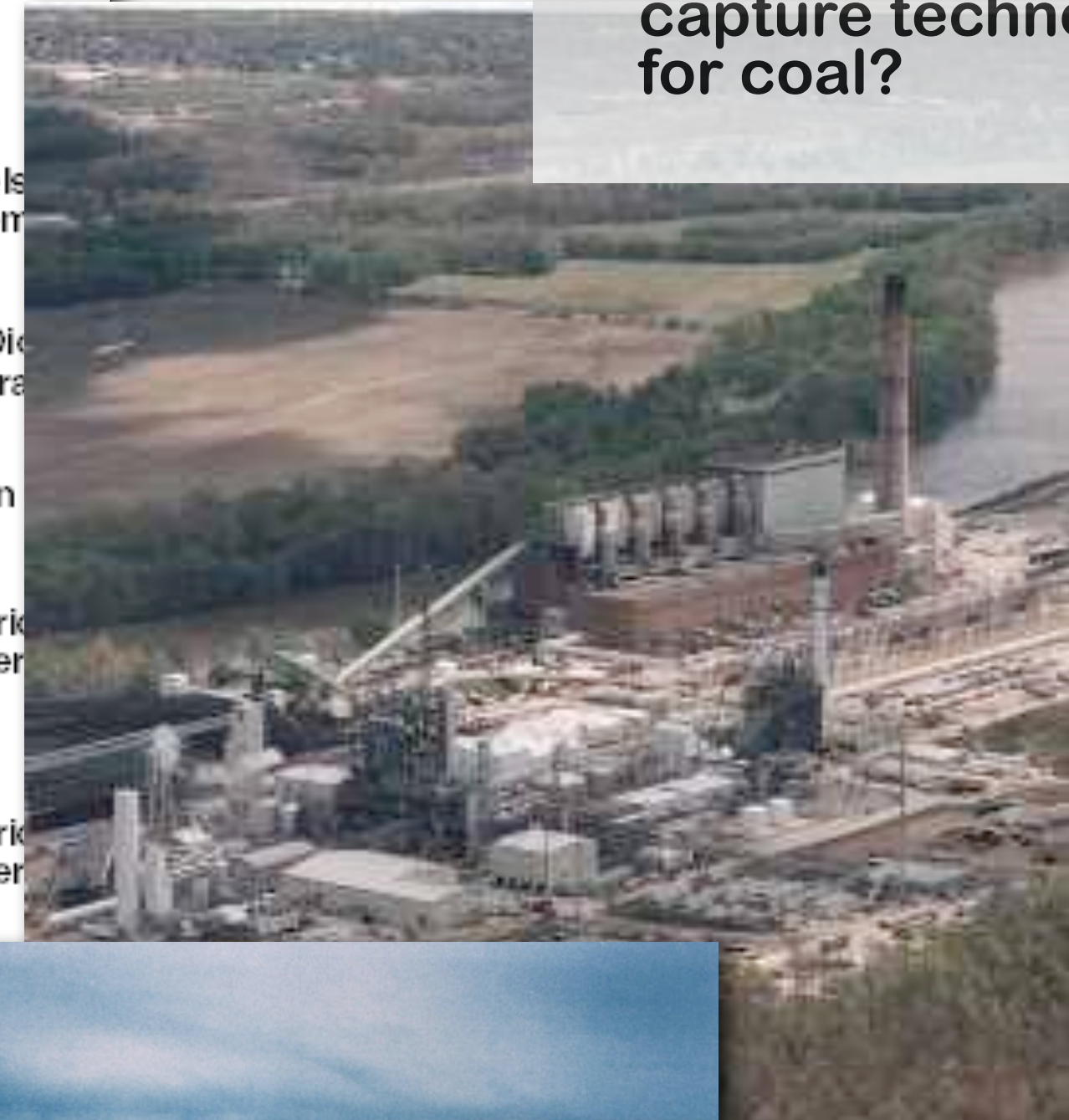
CO₂ Capture technologies

IGCC



CO₂ capture question:

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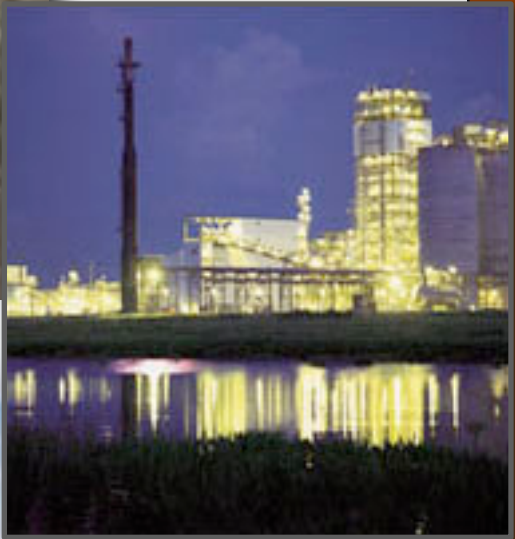
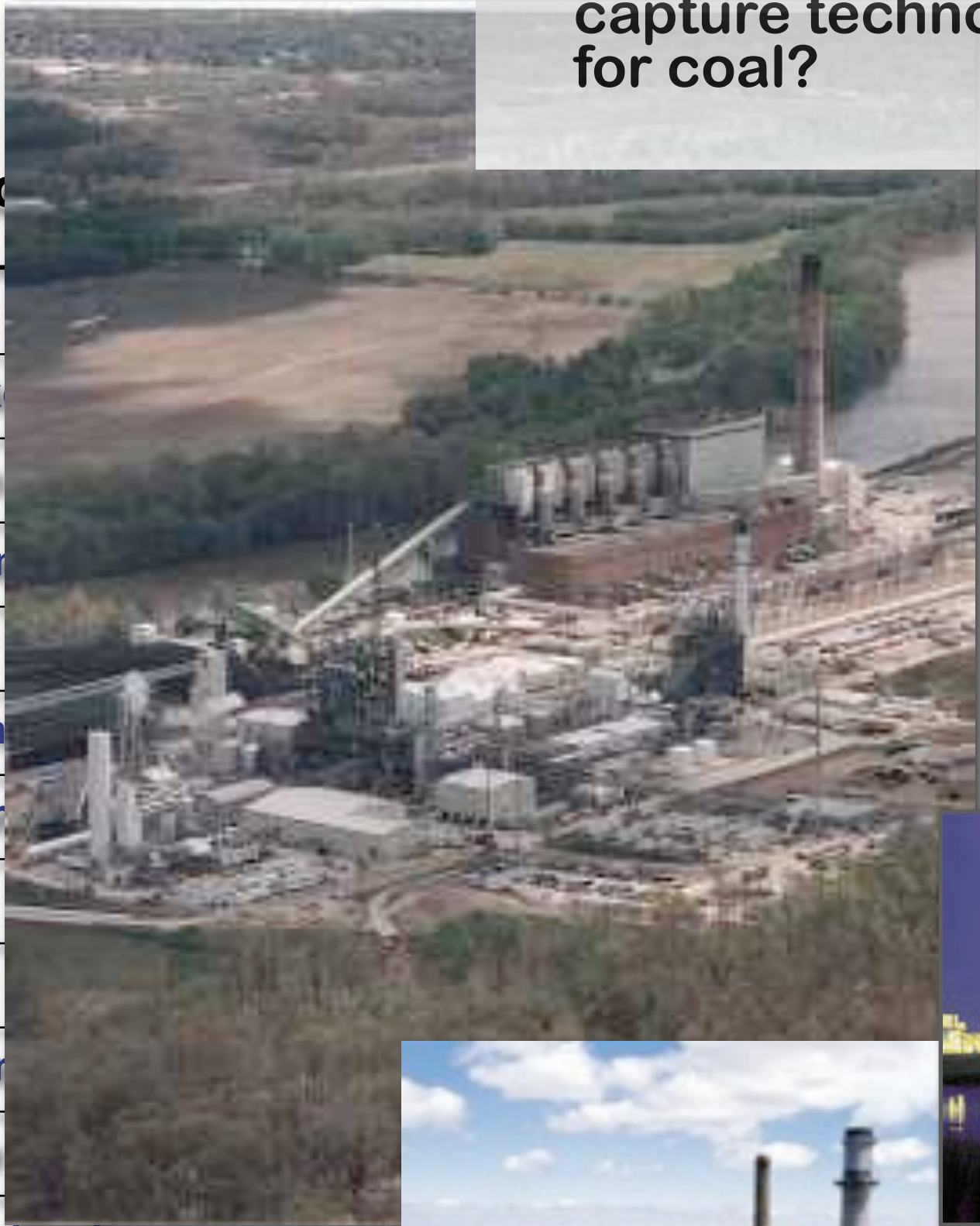
CO₂ Capture technologies

Commercial IGCC Projects (14)

CO₂ capture question:

- what are the CO₂ capture technologies for coal?

Project – Location	Start-Up	Megawatts	Products - Feedstocks
Nuon (Demkolec) – Netherlands	1994	250	Power / Coal
Wabash (Global/Cinergy) – USA	1995	260	Repower / Coal, Pet Coke
Tampa Electric Company – USA	1996	250	Power / Coal, Petroleum
Frontier Oil, Kansas – USA	1996	45	Cogeneration / Petroleum
SUV – Czech Republic	1996	350	Cogeneration / Coal
Schwarze Pumpe – Germany	1996	40	Power & Methanol / Lignite
Shell Pernis – Netherlands	1997	120	Cogen & H ₂ / Visbreaker
Puertollano – Spain	1998	320	Power / Coal, Coke
ISAB: ERG/Mission – Italy	2000	510	Power / Asphalt
Sarlux: Saras/Enron – Italy	2001	545	Power, Steam, H ₂ / Visbreaker
Exxon Chemical – Singapore	2001	160	Cogeneration / Ethylene
API Energia – Italy	2001	280	Power & Steam / Visbreaker Tar
Motiva LLC – Delaware, USA	2002	160	Repower / Pet Coke
Nippon Refining – Japan	2003	342	Power / Asphalt



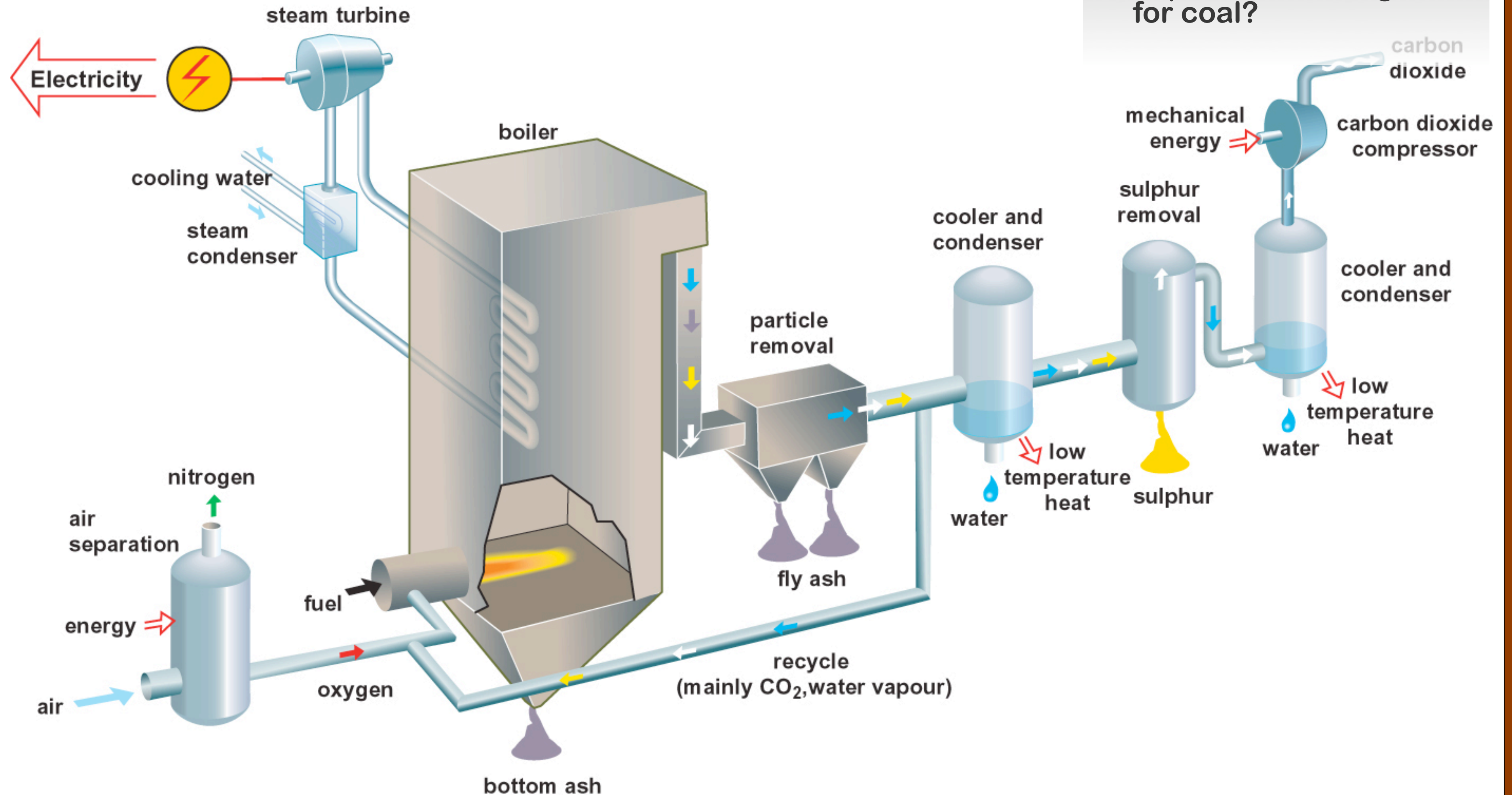
Total IGCC Megawatts – 3,632 MW
Total Experience, Operating Hours on Syngas > 750,000 hours

CO₂ Capture technologies

Oxy-Coal Combustion

CO₂ capture question:

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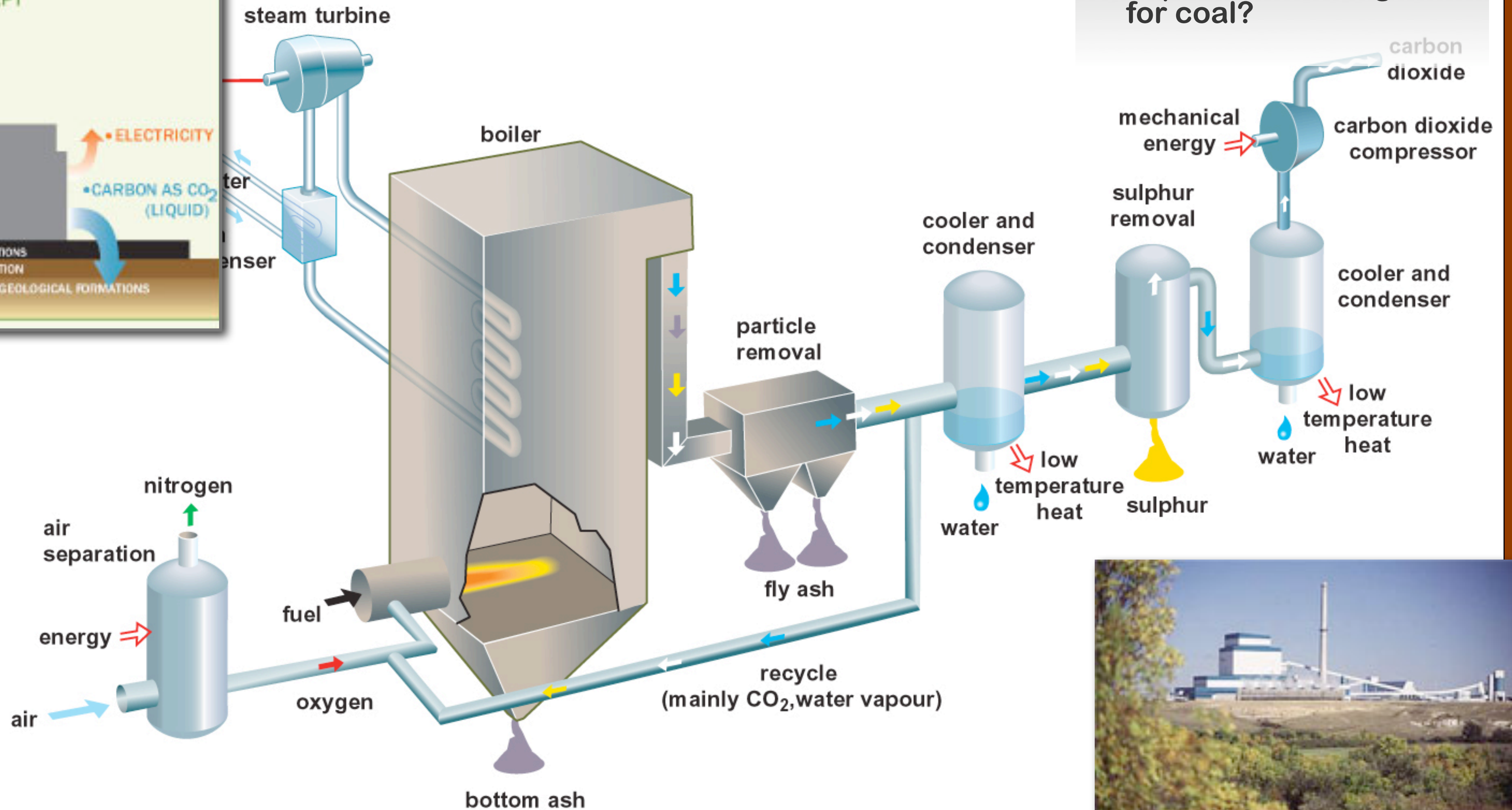
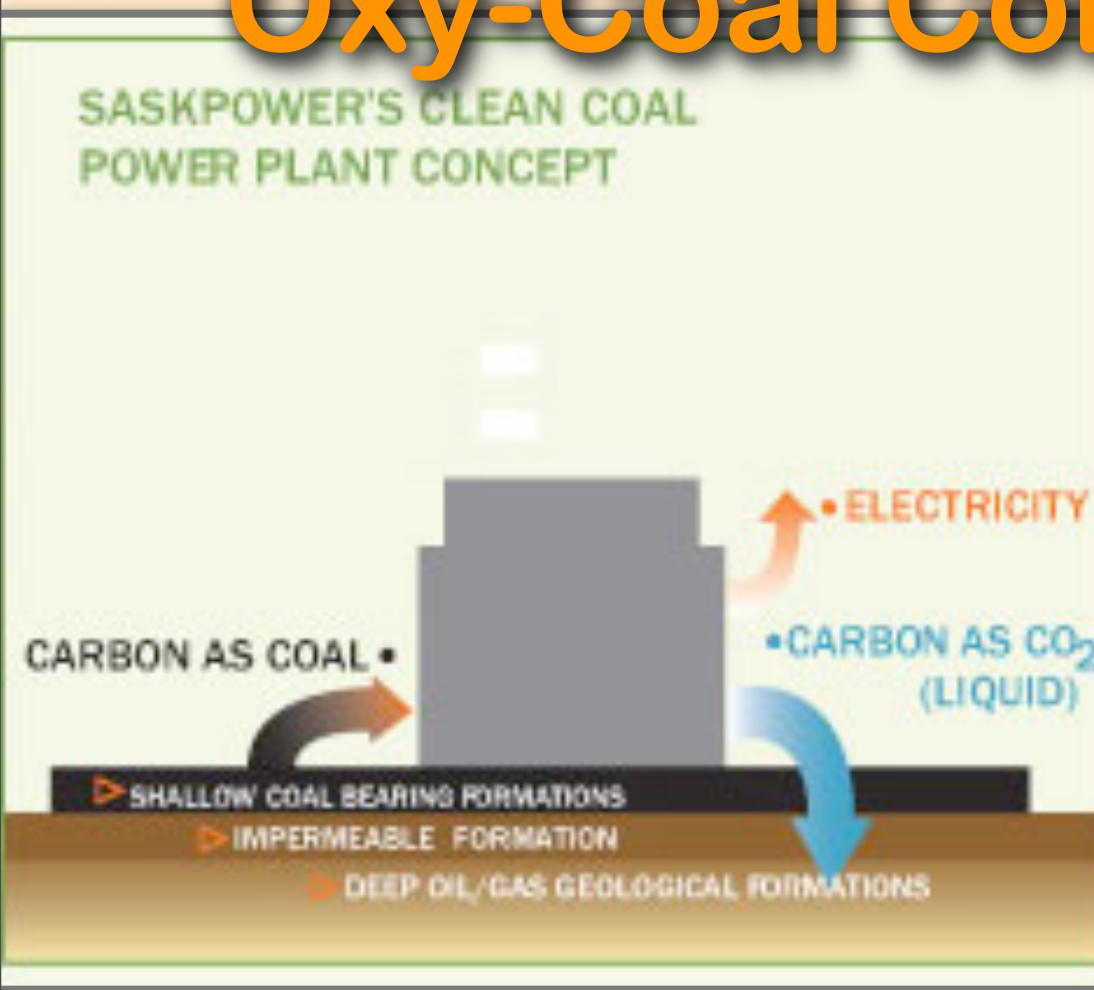
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CO₂ Capture technologies

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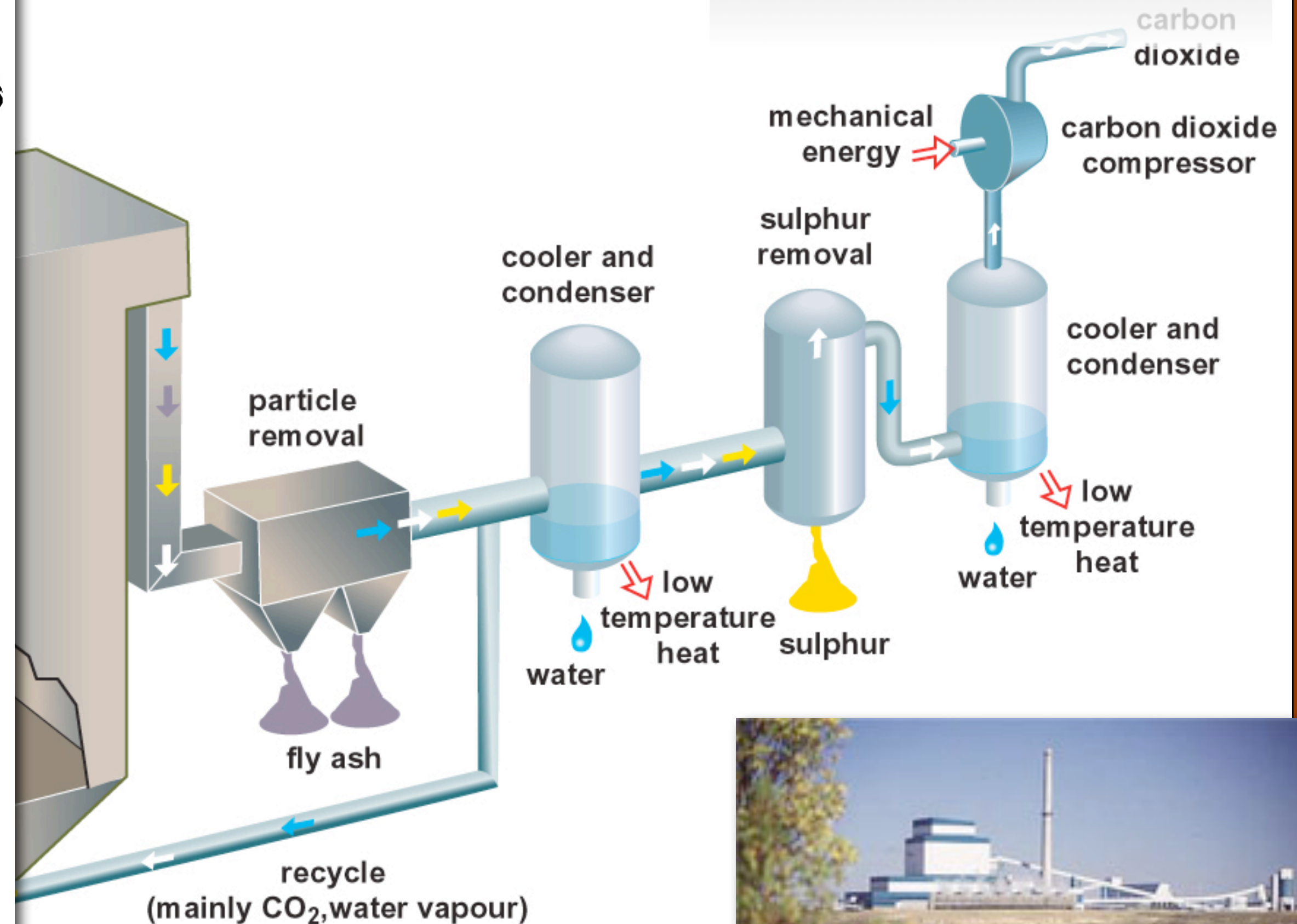
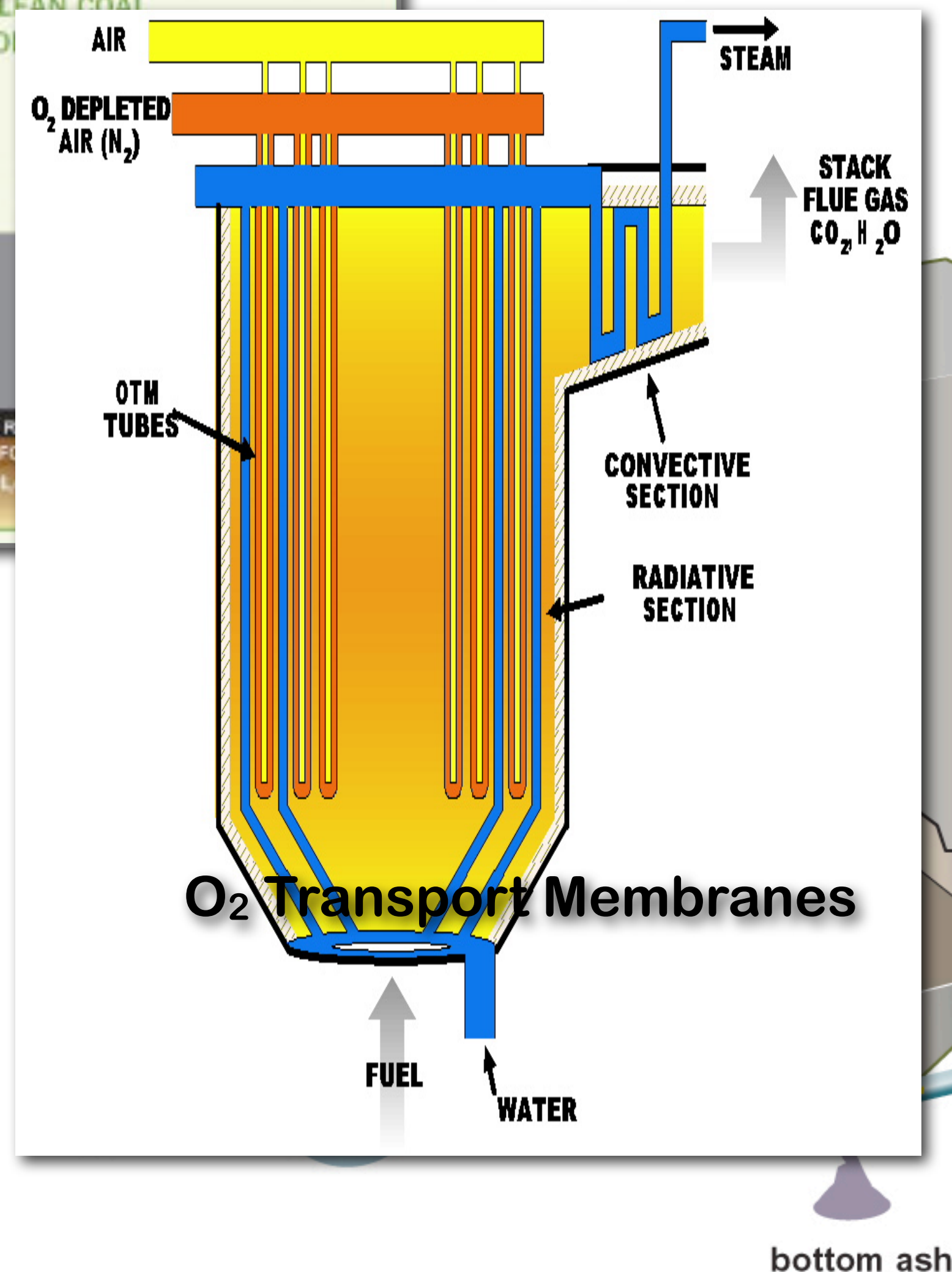


CO₂ Capture technologies

Oxy-Coal Combustion

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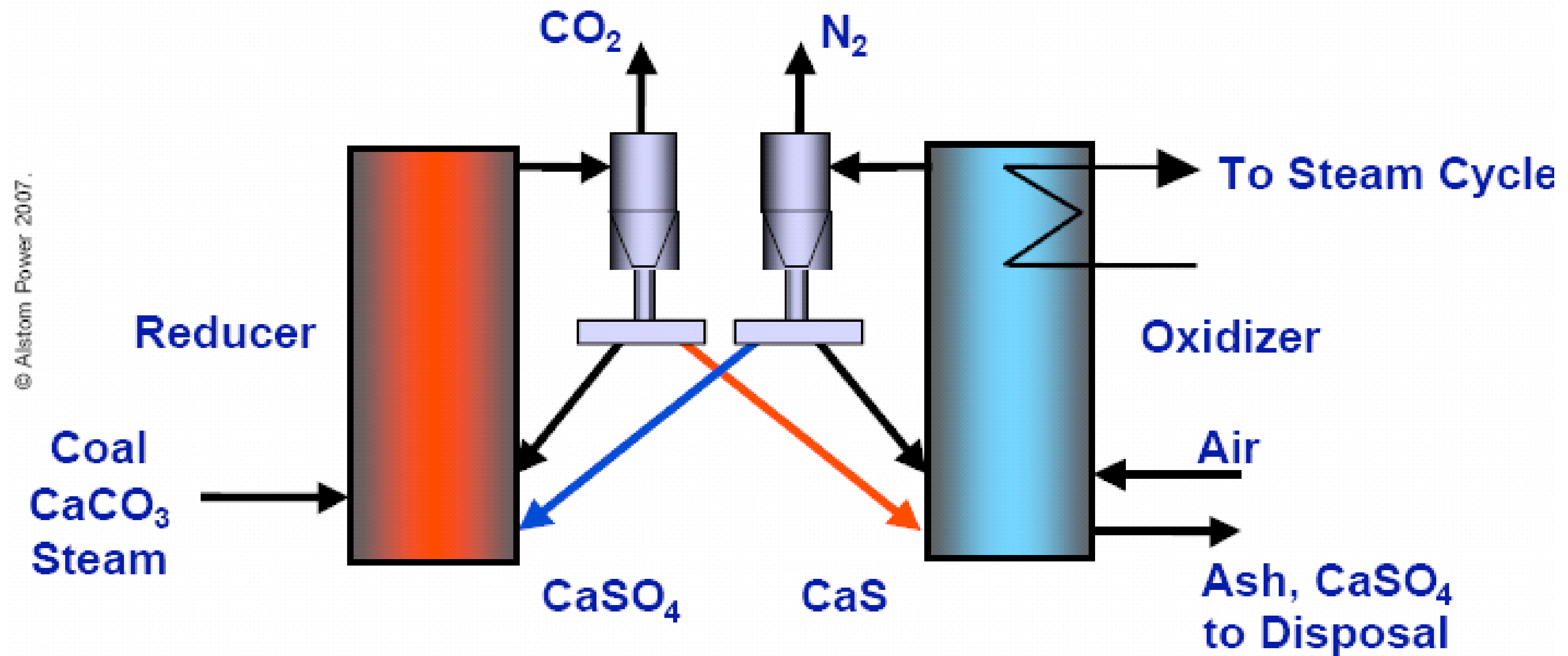
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CO₂ Capture technologies

Chemical Looping

CO₂ capture question:

- what are the CO₂ capture technologies for coal?

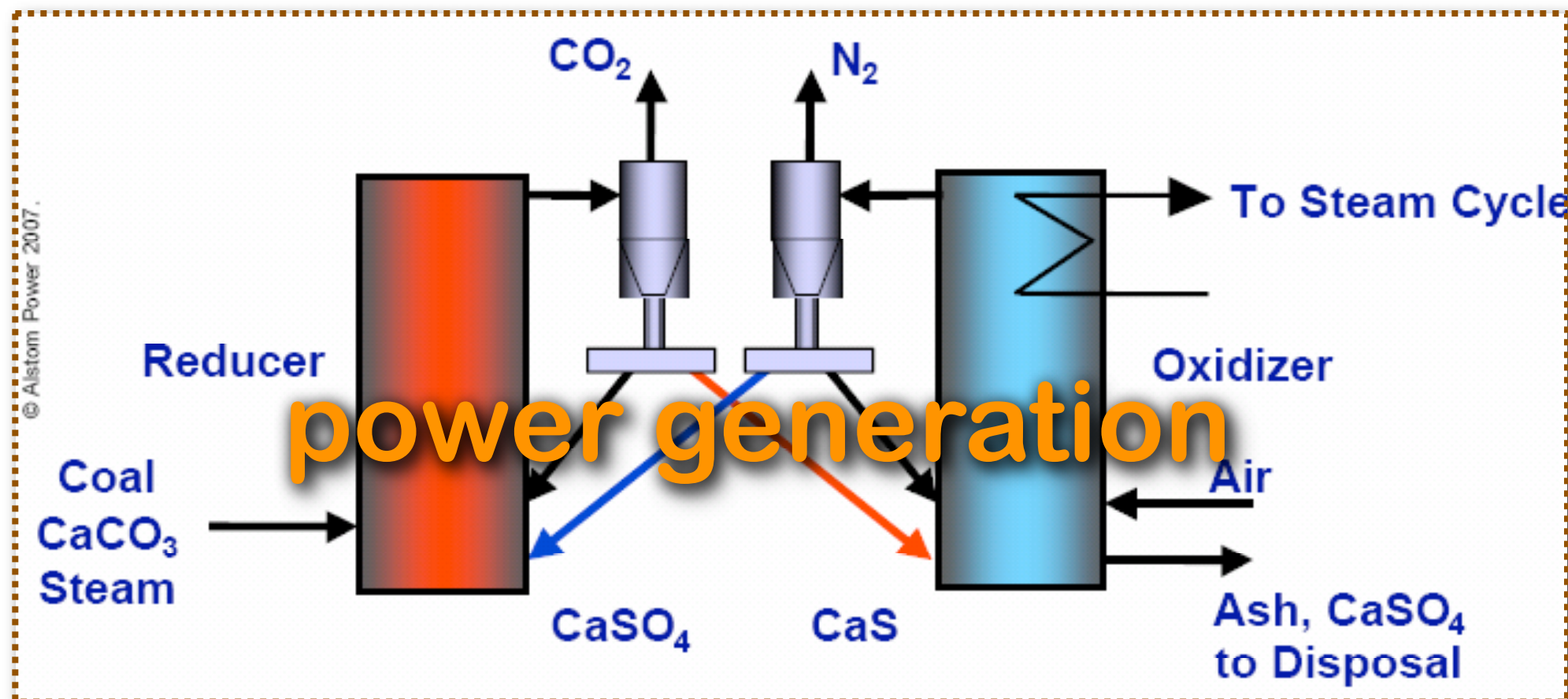


CO₂ Capture technologies

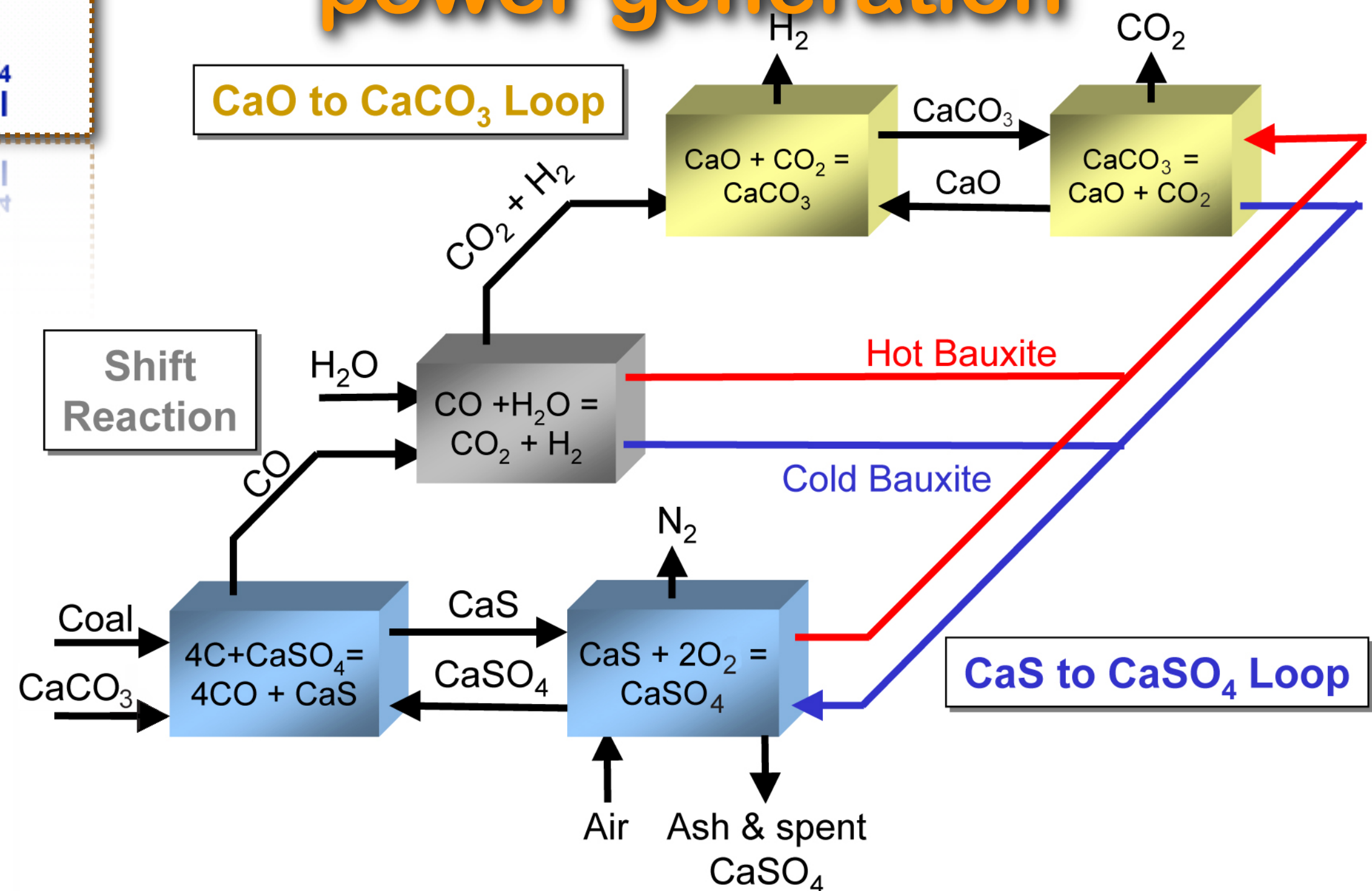
Chemical Looping

CO₂ capture question:

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combined
gasification &
power generation



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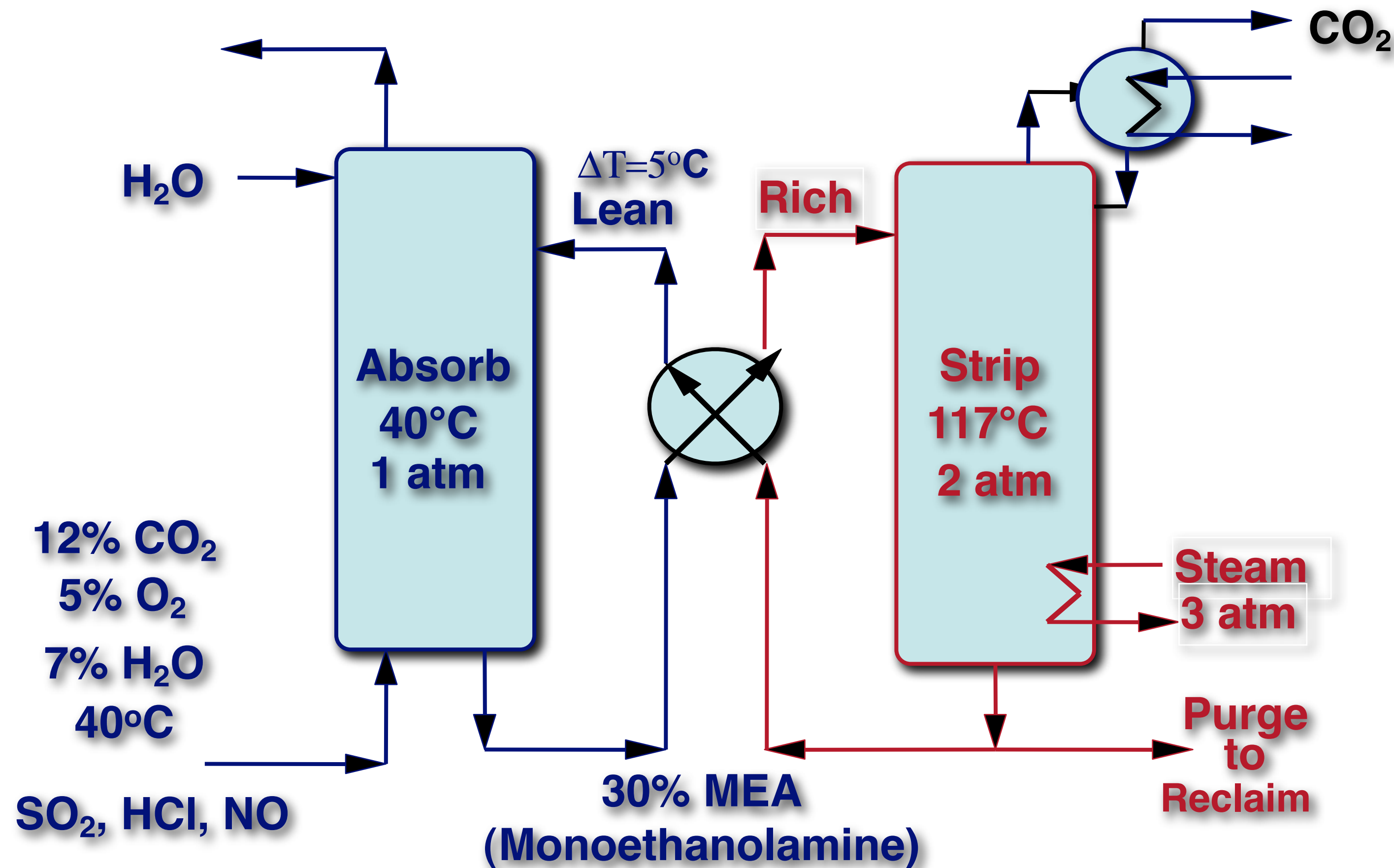
CO₂ Capture technologies

CO₂ removal from flue gas

MEA stripping

CO₂ capture question:

- what are the CO₂ capture technologies for coal?



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CO₂ Capture technologies

CO₂ capture question:

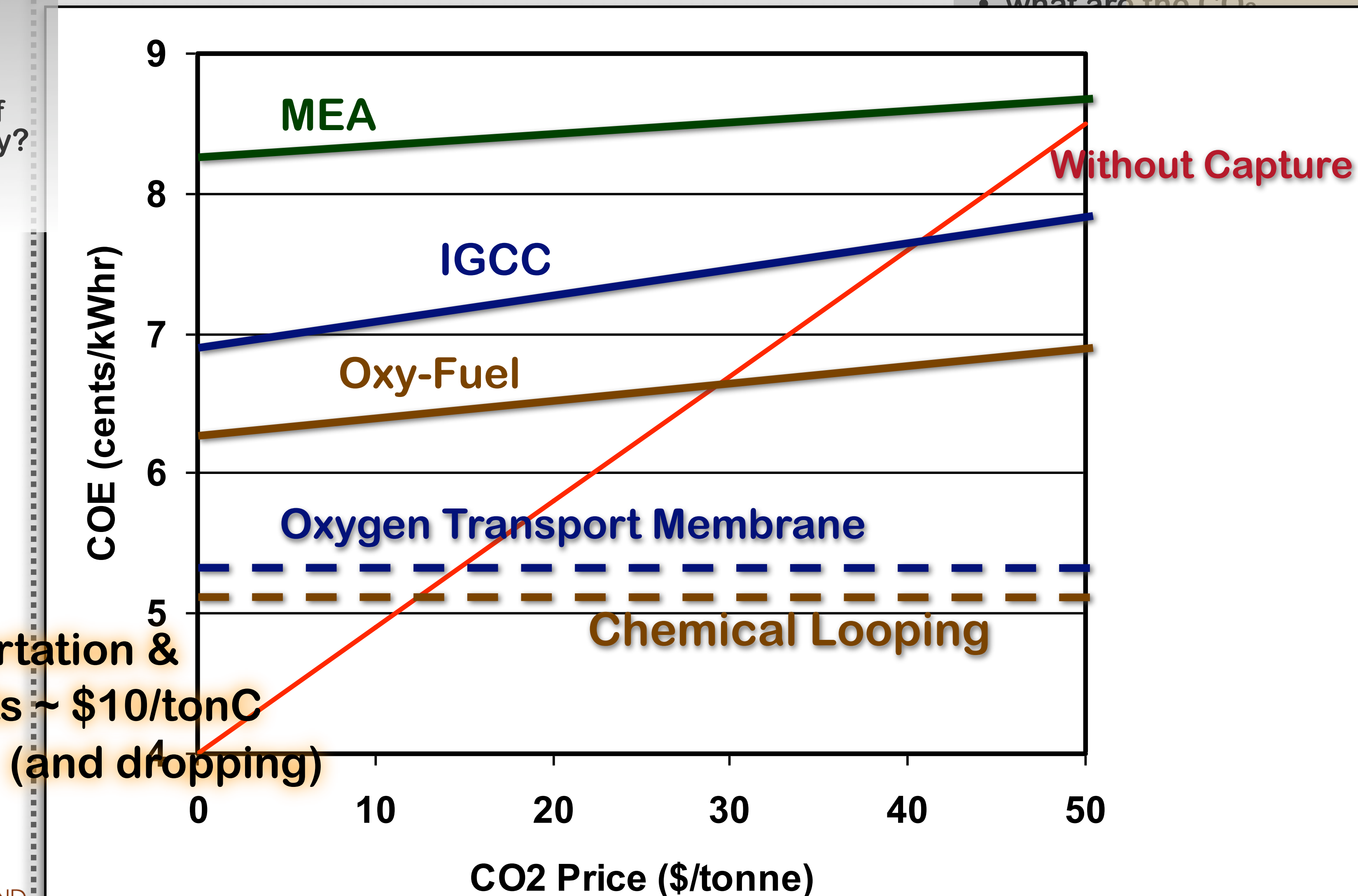
- what are the CO₂ capture technologies for coal?
 - post-combustion
 - oxy-fuel
 - pre-combustion

clean coal
implementation
question:

CO₂ capture technologies

CO₂ capture question:

- when will clean coal technology become commercial?
- what are the costs of clean coal technology?



CO₂ transportation &
storage costs ~ \$10/tonC
(and dropping)

source: MIT report on the Future of Coal



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SECURE ENERGY

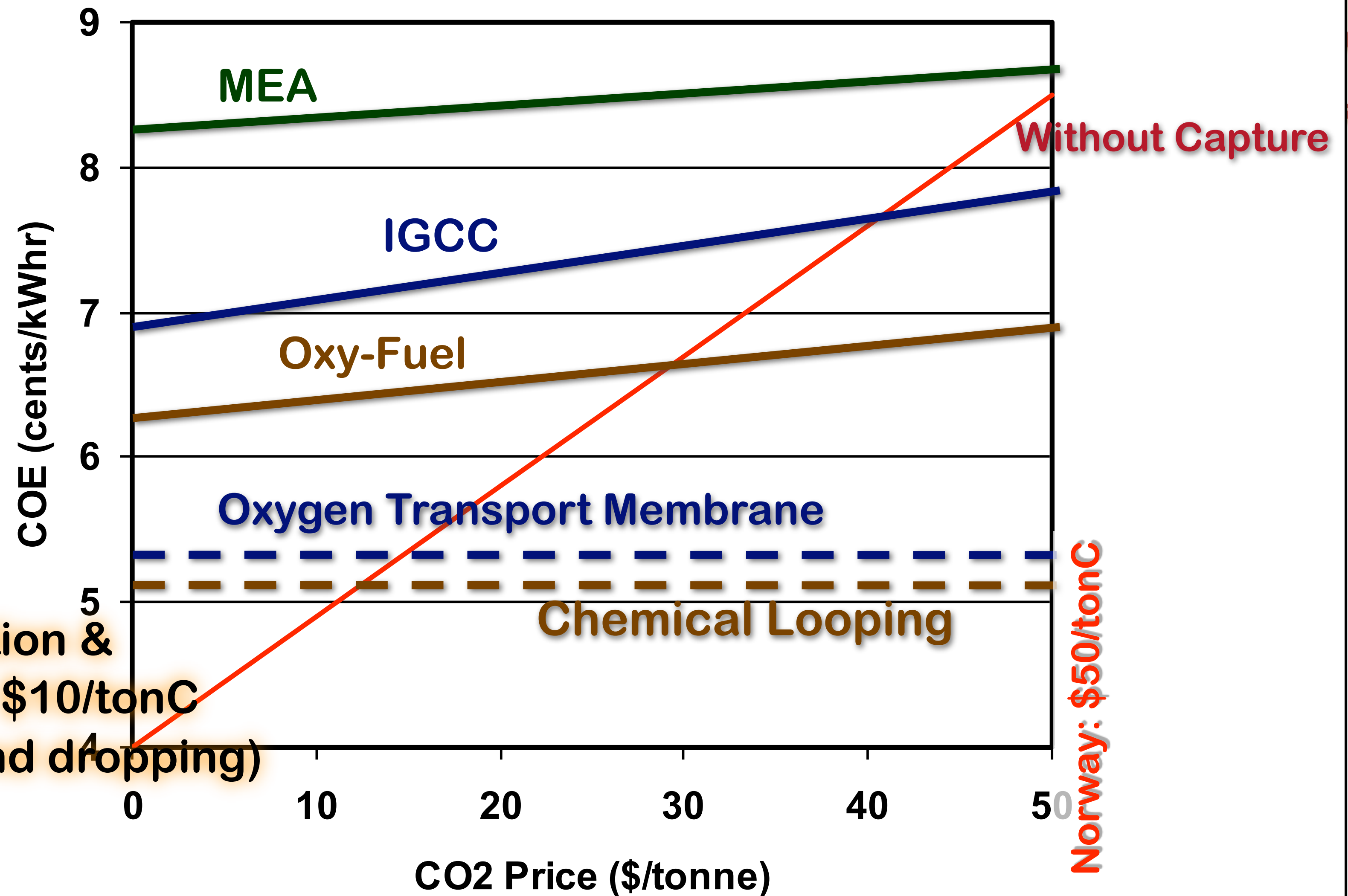
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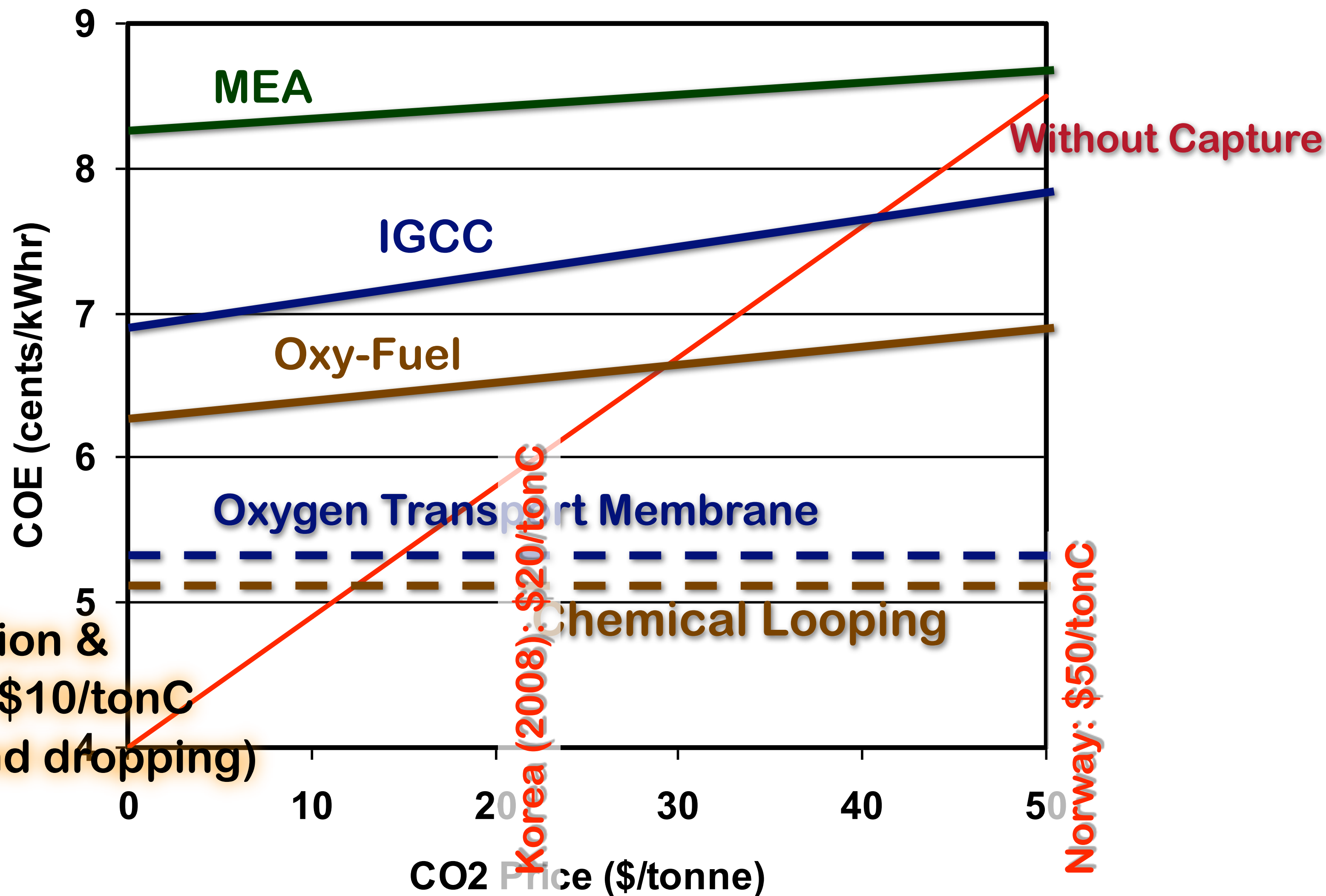
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CO₂ transportation &
storage costs ~ \$10/tonC
(and dropping)



source: MIT report on the Future of Coal



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clean coal
implementation
question:

CO₂ capture technologies

- when will clean coal technology become commercial? **soon - depending on CO₂ legislation**
- what are the costs of clean coal technology?

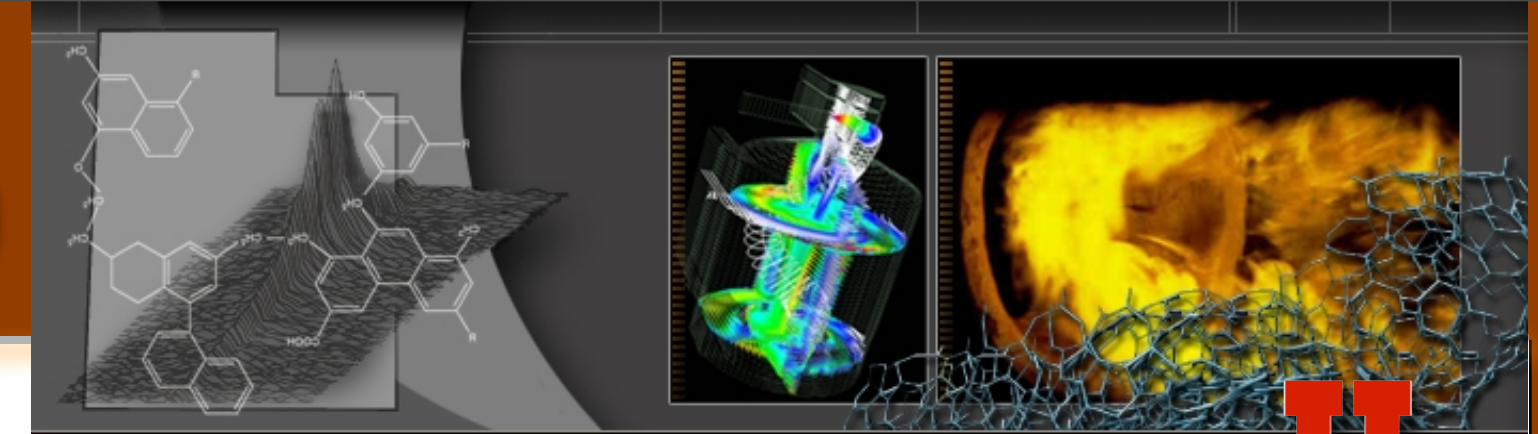
storage < \$10/tonC
capture > \$30/tonC

CO₂ capture question:

- what are the CO₂ capture technologies for coal?
 - **post-combustion**
 - **oxy-fuel**
 - **pre-combustion**



Utah Clean Coal Program



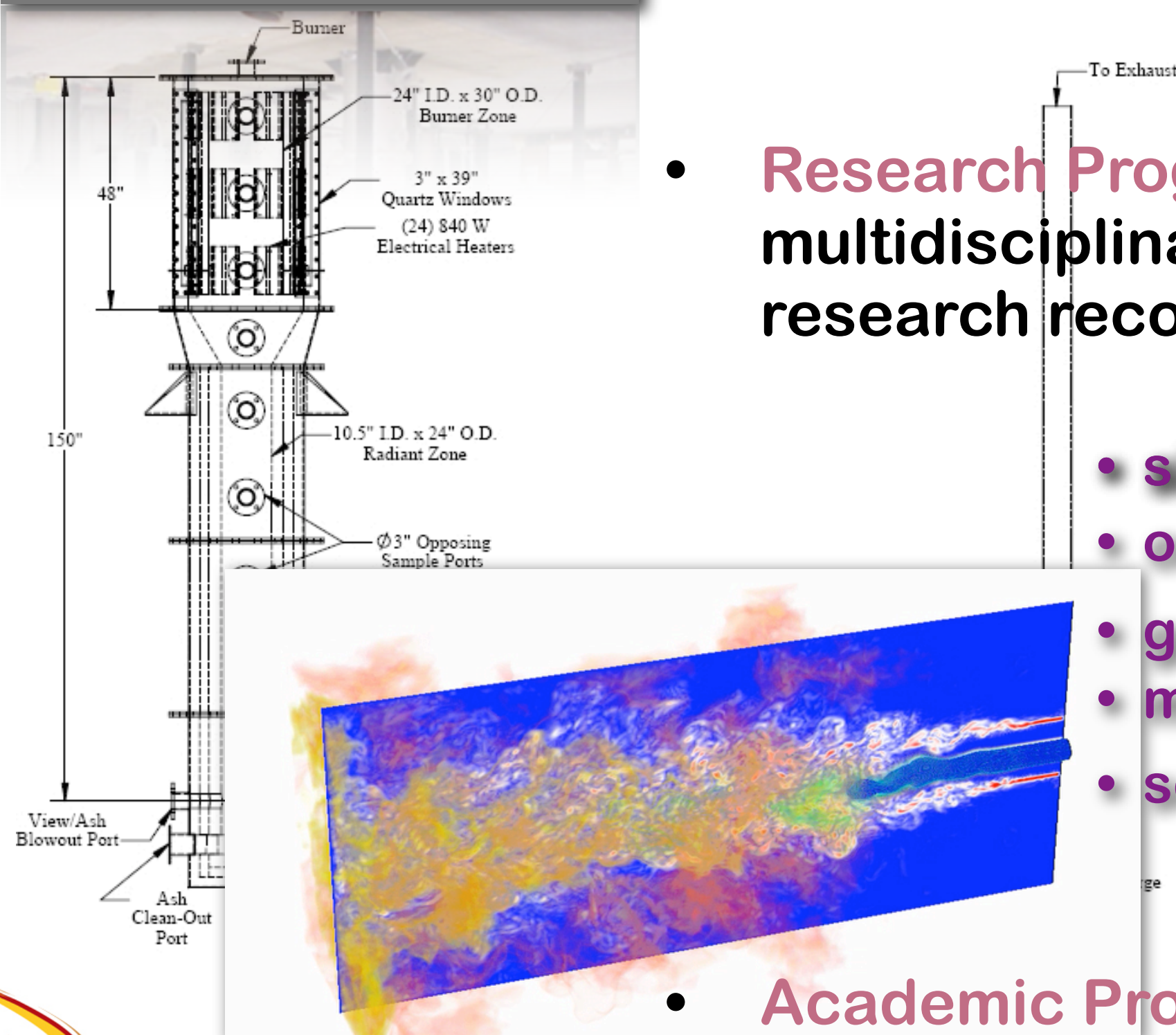
THE
UNIVERSITY
OF UTAH

- **Mission:** generate technical breakthroughs that allow coal to be used as a major clean energy source in a carbon-constrained world.

- **Research Program:** build on core competencies of a multidisciplinary team of faculty with distinguished research records.

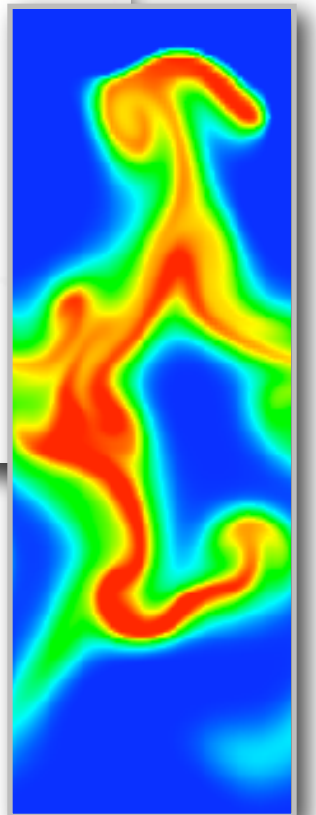
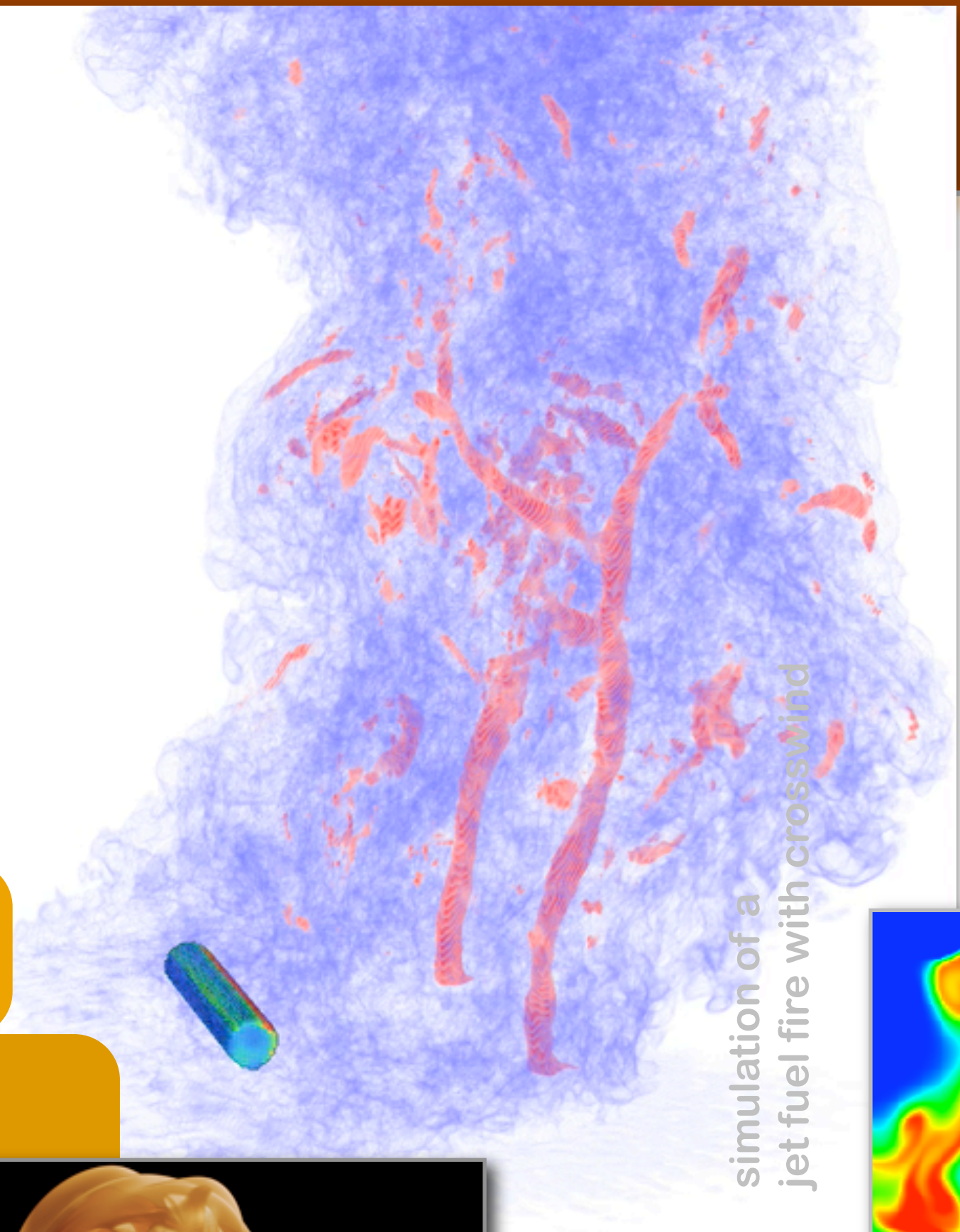
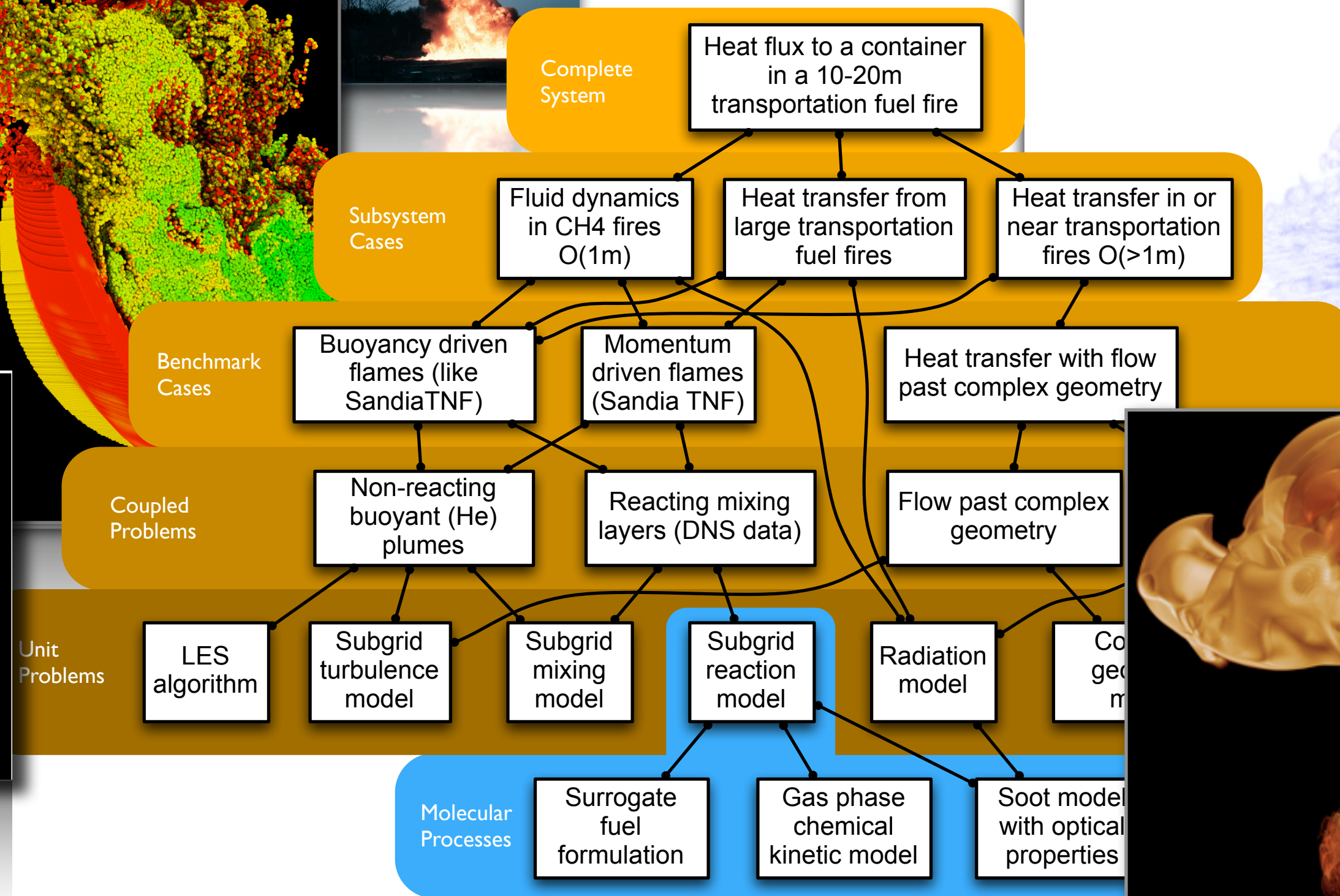
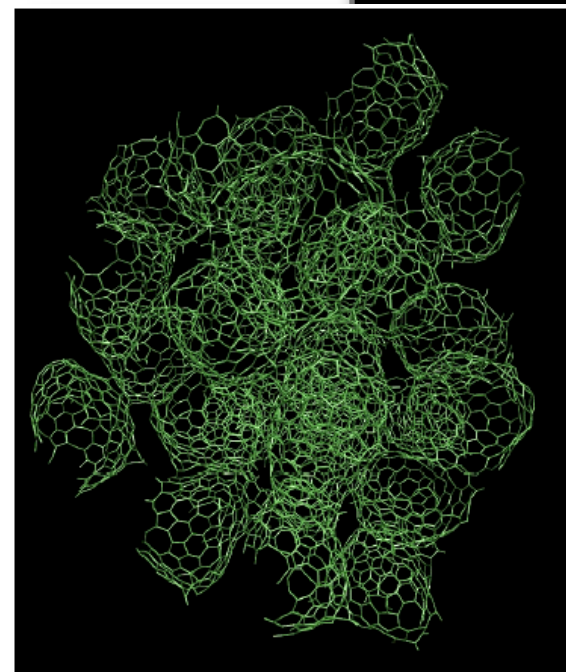
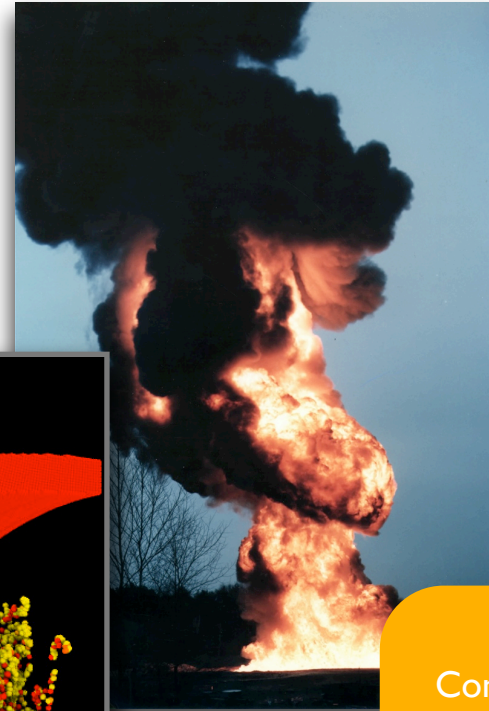
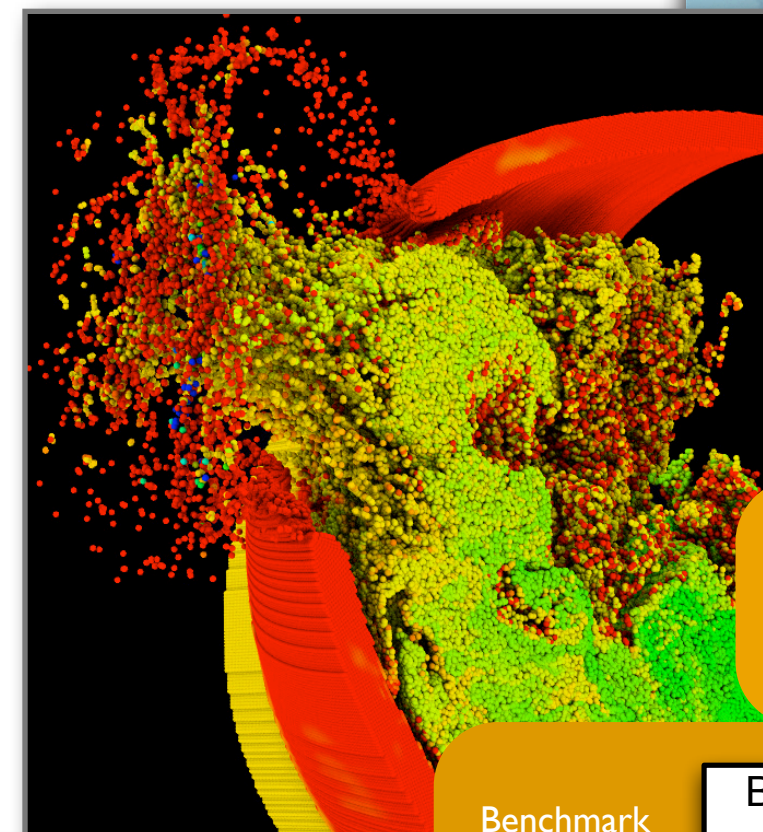
- simulation (Smith)
- oxy-fuel combustion (Wendt, Eddings)
- gasification (Whitty, Pugmire, Baxter, Fletcher)
- mercury control (Lighty, Silcox, Senior, Pugmire)
- sequestration (Deo, McPherson)

- **Academic Program:** train students in interdisciplinary energy needs & establish internships with industry, DOE, other centers



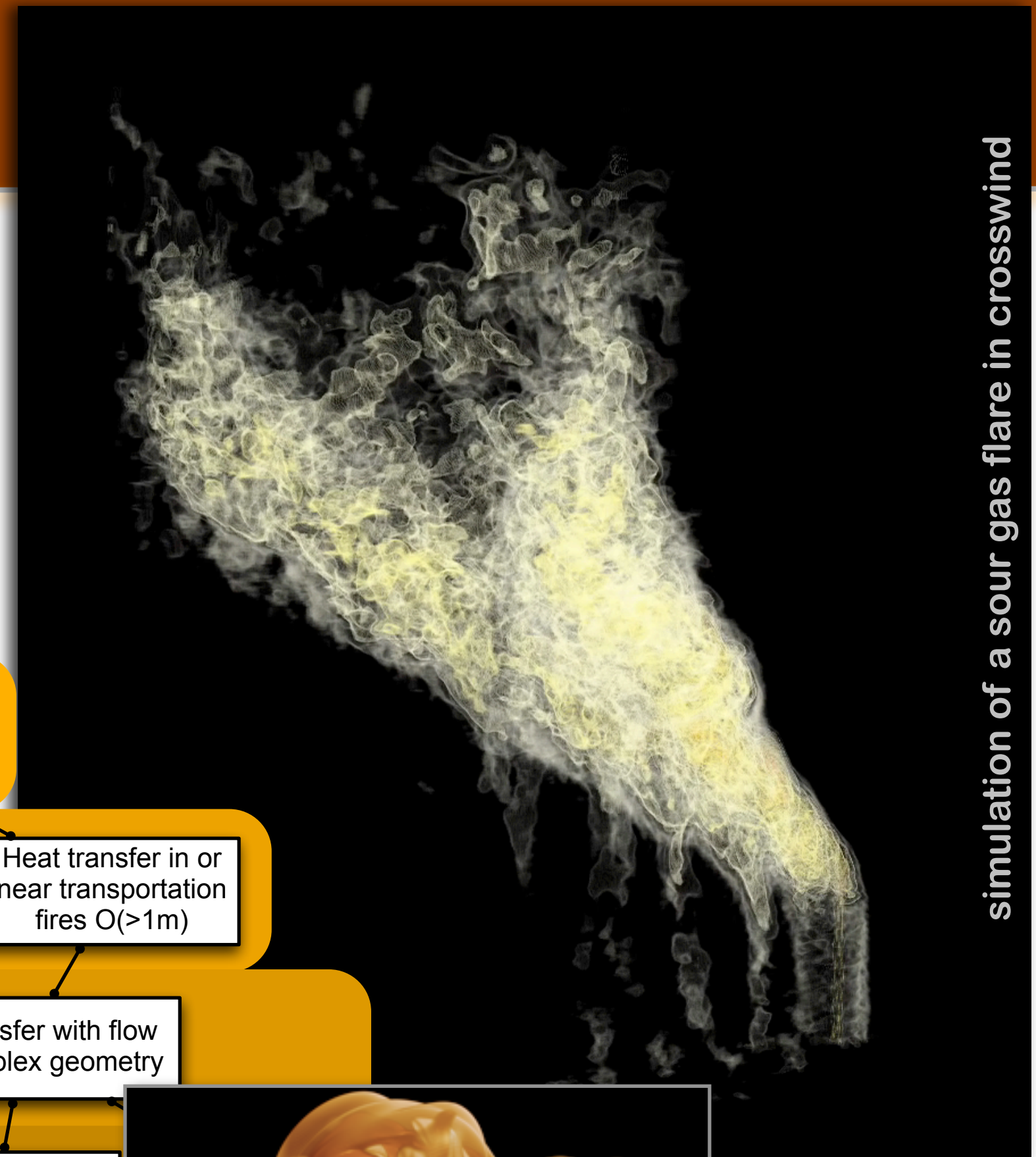
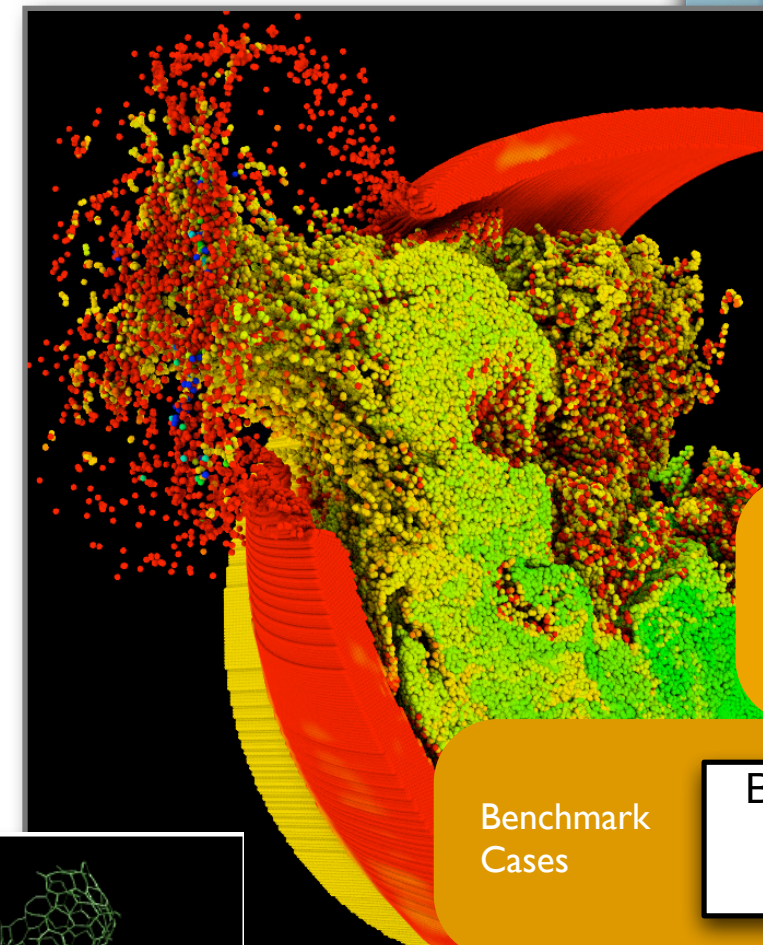
Center for Simulation of Accidental Fires & Explosions (C-SAFE)

- high fidelity simulation software for massively parallel computers
- thorough validation
- data intensive
- uncertainty quantification

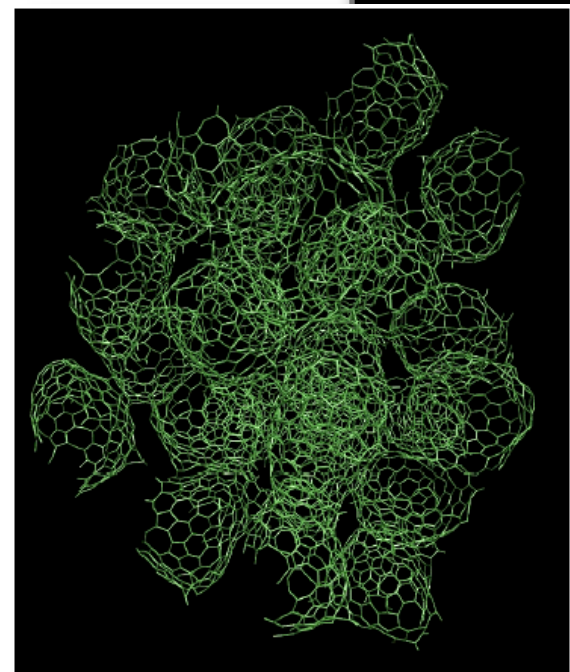
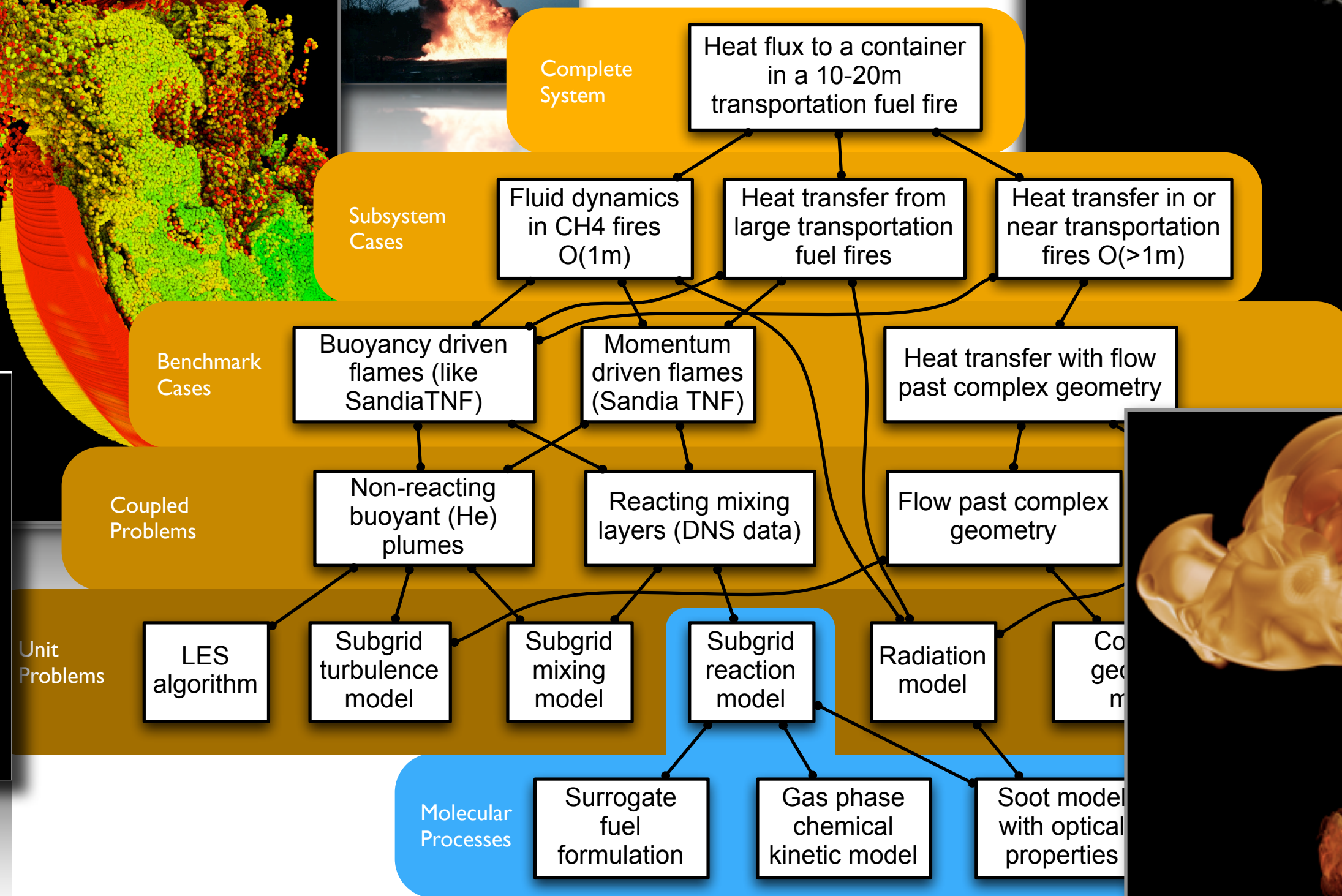
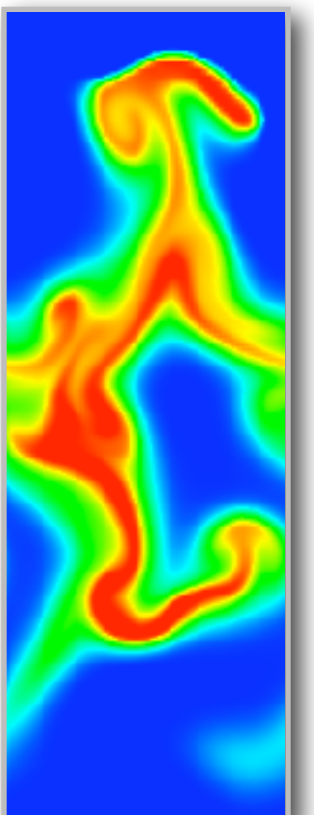


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simulation of a sour gas flare in crosswind



Sponsored Research Projects

Millennium Synfuels Project

- **Millennium Synfuels, LLC**
 - Joint venture between
 - Oil Tech ([Utah company](#))
 - Ambre Energy Ltd ([Australian company](#))
 - Development of technologies for alternative sources of oil (e.g., coal, oil shale)
- **Collaboration w/University of Utah**
 - Short-Term Program (9 mo.)
 - Assistance with retort technology to jump-start process development
 - Faculty: Eddings, Lighty, Silcox, Whitty
 - Fundamental experiments – rates, optimization
 - Process modeling
 - Assist w/pilot plant retort startup and operation (plant located near Vernal, UT)
 - Long-Term Research Programs (multi-year)
 - Di-Methyl Ether (DME) Synthesis
 - Faculty: Jan Miller, Wlodzimierz Zmierczak
 - Other Programs
 - Exploring potential for long-term research efforts related to their retort technology and coal gasification





Energy & Geoscience Institute
at the University of Utah

- 70 EGI scientists & staff are a cost-shared laboratory
- Largest University based petroleum research consortia in world with 60+ corporate members in 21 countries
- Cooperation with > 40 International Organizations
- Largest DOE University Geothermal program in USA
- New Carbon Engineering Group for CO₂ Sequestration
- Delivered > \$250 Million dollars of research

Calgary

Houston

Salt Lake

London

Sydney



61 Energy Industry

Corporate Associate Members



Anadarko - KMG

Anzon Energy

Apache

Benchmark

British Gas

BHPBilliton

BP

BPC Ltd.

Centrica

Chevron

Cobalt International

ConocoPhillips

Devon

DNO

El Paso

EnCana

Eni

Frontera

Gaz de France

Hess

Hunt Oil

Lukoil

Lundin

Maersk Oil

Marathon

Mitsui

Murphy Oil

Nations Energy

Newfield

Nexen

Nippon

Noble Energy

Norsk Hydro

Occidental

Oil Search

Oil India

OMV

Ophir Energy

Petrobras

Petronas

Petro-Canada

Pioneer

Pogo

Premier Oil

Red Leaf

Reliance

Remora Energy

Repsol YPF

ROC Oil

RWE Dea

Samson

Shell

Sipetrol

Statoil

Talisman

Teikoku Oil

Terralliance

Total

Tullow

Wintershall

Woodside

CENTER Research

- Radiation Dose Reconstruction/ Assessment
 - Health effects-stochastic and deterministic
 - Plutonium and Americium metabolism/ biokinetic modeling
 - Chelation therapy for plutonium intakes
- Radiation Hardening/Materials Damage
 - Dynamic materials testing (in core)
 - New reactor materials development
- Fuel Reprocessing Modeling and Separation
- Neutron Imaging, Detector Development
- Energy Management and Savings



INSTITUTE FOR CLEAN AND
SECURE ENERGY

● 155 SOUTH 1452 EAST ROOM 380 ● SALT LAKE CITY, UTAH 84112 ● 801-585-1233

ICSE interdisciplinary research,
technology & academic programs
in hydrocarbon energy

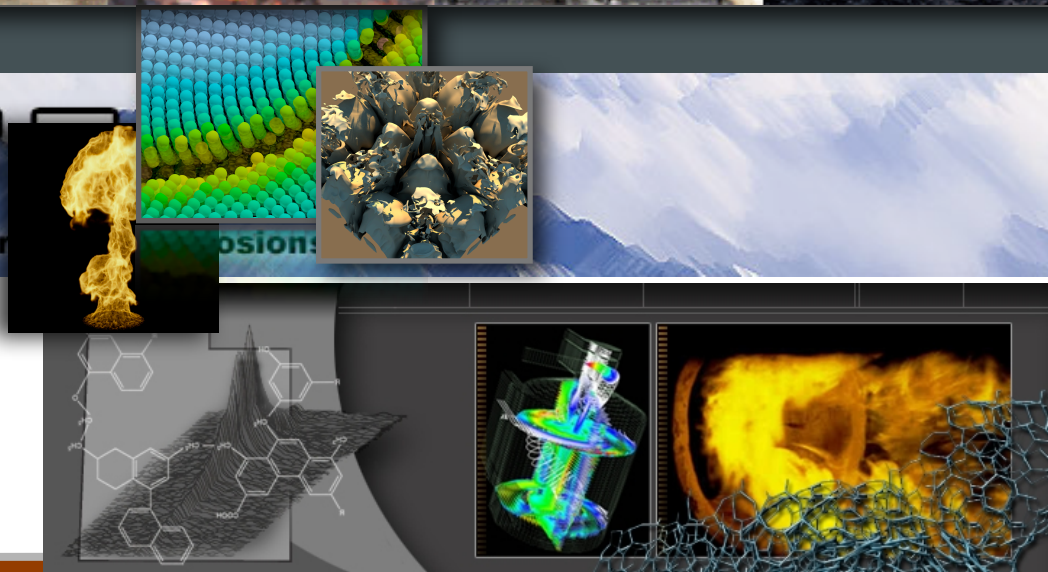
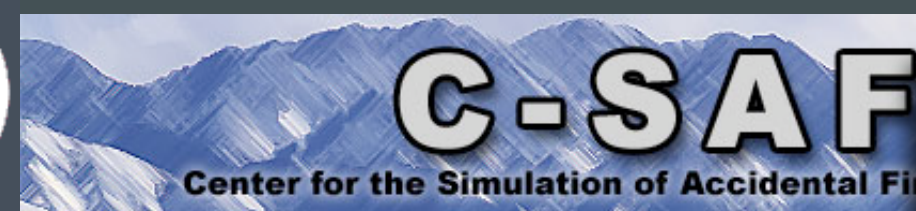
CENTER

T h e U n i v e r s i t y o f U t a h

UHOC: Utah Heavy Oil Program

C-SAFE: Center for Simulation of
Accidental Fires & Explosions

UC³: Utah Clean Coal Program



EGI

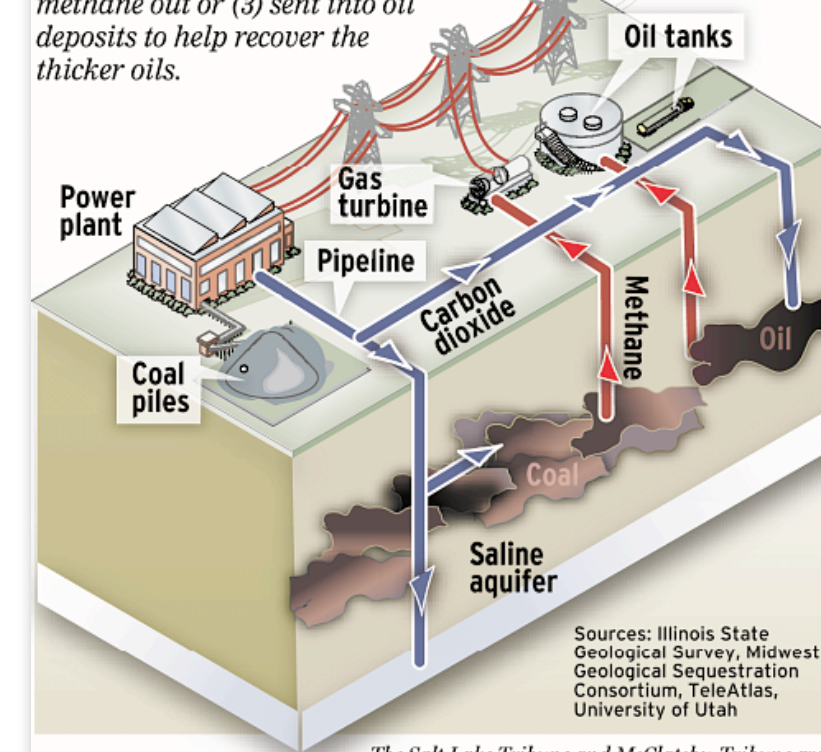
Energy & Geoscience Institute
at the University of Utah



The Book Cliffs photo by Harry Barber

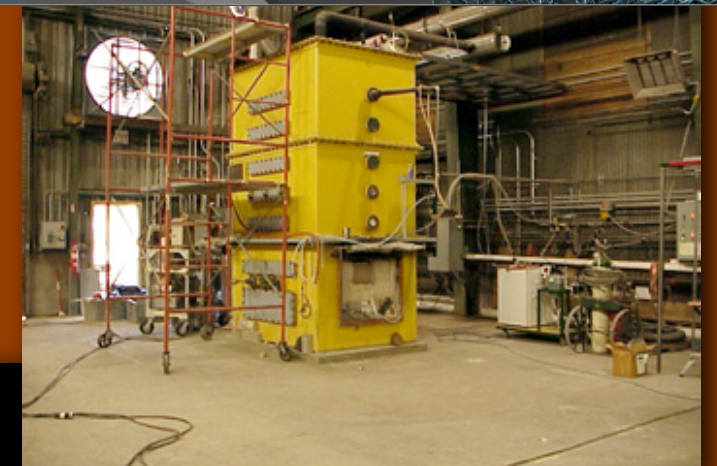
Carbon Sequestration Methods

The University of Utah's Clean Coal Program explores ways that utility companies with coal-fired power plants can reduce carbon dioxide emissions, which are a major contributor to global warming. Carbon dioxide could be (1) pumped into saline aquifers for storage, (2) forced into coal beds deep underground to push methane out or (3) sent into oil deposits to help recover the thicker oils.



Sources: Illinois State Geological Survey, Midwest Geological Sequestration Consortium, TeleAtlas, University of Utah

The Salt Lake Tribune and McClatchy-Tribune graphic



THE UNIVERSITY OF UTAH



question:

UHOC: Utah Heavy Oil Program

C-SAFE: Center for Simulation of Accidental Fires & Explosions

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CENTER

Energy & Geoscience Institute
at the University of Utah

The University of Utah

•what is the future of
energy research?









The Book Cliffs photo by Harry Barber

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Energy & Geoscience Institute at the University of Utah

The University of Utah

•what is the future of energy research?

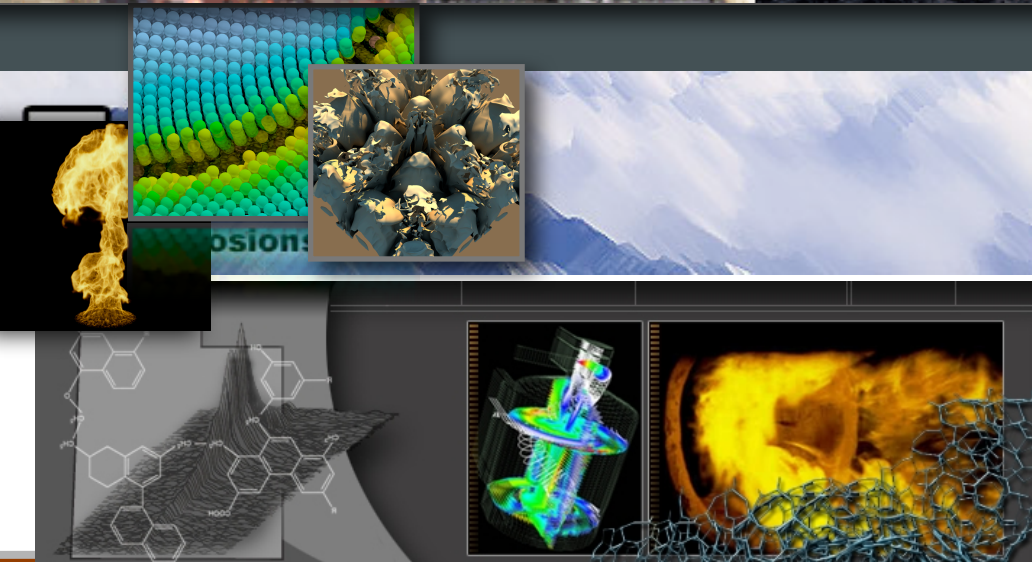
predictive science coupled with validation will be a tool for the discovery of low-cost, clean & safe energy options



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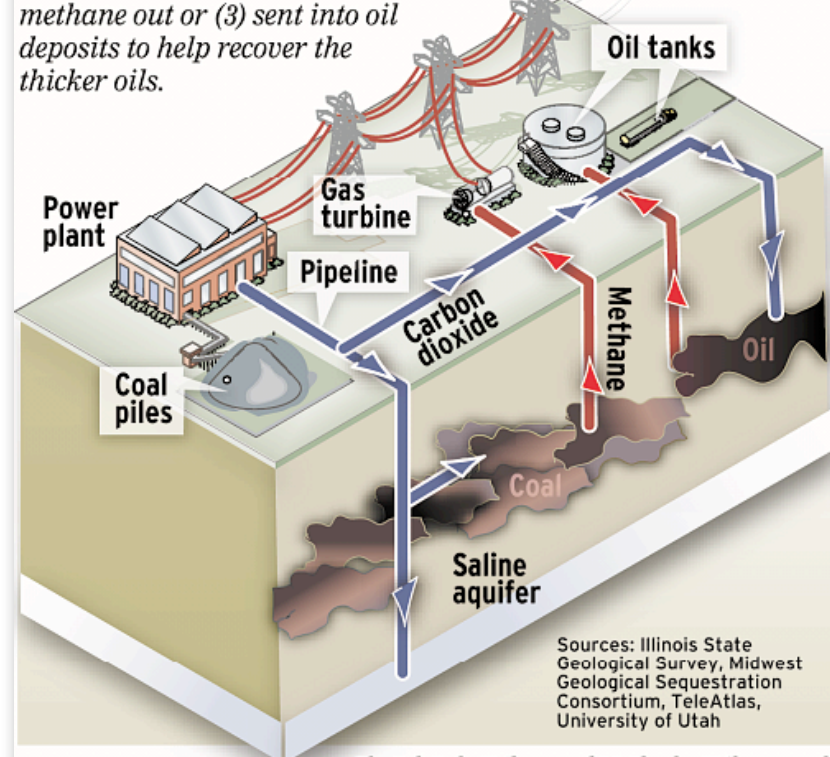
EGI



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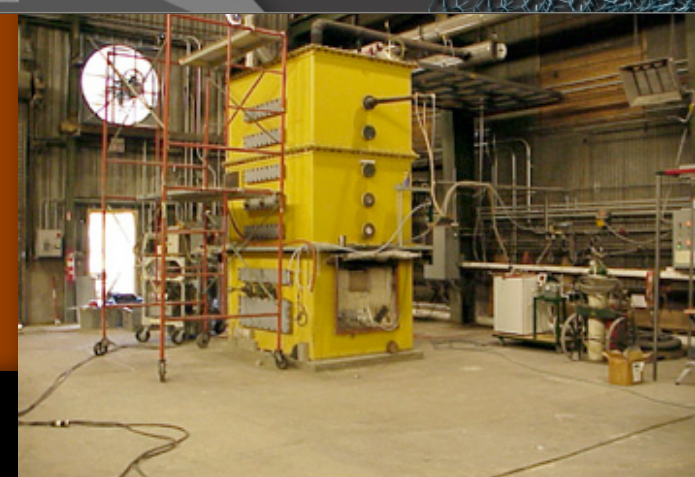
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THE UNIVERSITY OF UTAH

